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Philip Fox
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By OLIVER JUSTIN LEE

Philip Fox has gone. The friendly, generous, versatile astronomer, soldier, administrator, and notable cosmopolitan personality, whom we loved and admired as Philip Fox, is no longer with us. He will be missed and his memory will be cherished in more and larger circles than any of us will ever know.

Philip Fox, son of Adjutant General of Kansas, Simeon M. and Esther (Butler) Fox, was born in Manhattan, Kansas, on March 7, 1878. He received his B. S. degree from Kansas State College in 1897. On June 16, 1898, he enlisted as a private for the Spanish American War. He served in the campaigns against the Moros of the Philippine Islands until he was mustered out on October 28, 1899, having been promoted to a second lieutenancy on the field of battle for heroism in action. In the fall of 1899 he accepted the position of commandant and teacher of mathematics at St. John's Military School, Salina, Kansas, remaining there for two years. In 1901 he was given an M. S. degree by Kansas State College.

At the suggestion of his famous cousin, Ernest Fox Nichols, then professor of physics and later president of Dartmouth, he studied there for a year as a senior, and received Dartmouth's B. S. degree in 1902. He remained for another year as assistant in physics.

Upon the invitation of George Ellery Hale and Edwin Brant Frost, he became Carnegie Assistant at the Yerkes Observatory of the University of Chicago for two years.

In August, 1905, he married Ethel L. Snow of Chicago and spent a year, on leave from Yerkes, studying at the University of Berlin, where he established lasting friendships with such men as Hartmann, Ludendorf, and other continental astronomers, mathematicians, and physicists of that day. Upon his return he resumed his work at Yerkes as instructor in astrophysics and continued there until 1909, when, upon the nomination of Henry Crew, he was appointed to the position of professor of astronomy and Director of Dearborn Observatory at Northwestern University, where he remained until his resignation in 1929.

Immediately after this he became organizer and director of the new Adler Planetarium and Astronomical Museum in Chicago. During his eight years in this position he created a notable new cultural institution, rich in program and exhibits, which has been visited and enjoyed by millions of people, residents of Chicago and the middle west, and

visitors to the Century of Progress from all over the world, in 1933-34. On one trip to Europe he was able to secure for the Adler Museum a very notable private collection of astronomical and horological instruments of great historical and artistic value.

Fox's ability as a developer and organizer had become well known to many of the civic leaders of Chicago. It was not surprising that they persuaded him to take over the directorship of the Chicago Museum of Science and Industry. In the period 1937-42, he was able to complete many of the exhibits in that great museum and to plan many others.

During World War I he became a major in the Infantry in May, 1917, and served in France as Lt. Colonel and Assistant Chief of Staff. He returned to this country on September 23, 1919, and resumed his work at Dearborn.

In March, 1941, he was recalled to active duty as a colonel and was assigned to the position of Commanding Officer of Gulf Coast Recreational Areas with headquarters at Mobile, Alabama. In May, 1942, he was transferred as colonel in the Signal Corps and designated as Commanding Officer of the Signal Corps Schools at Harvard University. In September that year, upon the activation of the Army Electronics Training Center at Harvard, he became Commanding Officer of the Center. In September, 1943, he was retired from the army for age, but was presently appointed Lecturer on Electronics at Harvard University, a position he held until his death from cerebral thrombosis on July 21, 1944. Upon request of Harvard University, a military funeral service was held in the Harvard Chapel. Two small boys whom he had befriended marched soberly in the funeral procession between the lines of his military and civil associates. His ashes were buried, with military escort from Fort Riley, in the cemetery where his mother and father were interred, in Manhattan, Kansas.

Fox received many honors and marks of recognition while he lived. He was a Fellow of the American Academy of Arts and Sciences, of the American Association for the Advancement of Science (Secretary of Section D 1925-33, Vice-President Section D 1937, Member of the Executive Committee 1933-35), and of the Royal Astronomical Society of London. As member of the American Astronomical Society he served as Secretary 1912-18, Councilor 1921-23, and Vice-President 1938-40. He was a member of the Société Astronomique de France and of the Astronomische Gesellschaft. His fraternal affiliations were—social, Alpha Delta Phi, Phi Kappa Phi; honorary, Phi Beta Kappa, and Sigma Xi. He was also a mason. He was Chevalier, Legion d'honneur, and Officier de l'Ordre du Sauveur de la Gréce. He received the LL.D. degree from Drake University in 1929, and the D. Sc. degree from Kansas State College in 1931.

Fox was strongly influenced in his scientific work by the leaders with whom he came in contact. His two years with Nichols at Dartmouth opened to him the larger views of a career in science.

At Yerkes, Hale and Frost gave him opportunities for research, which he seized upon eagerly and developed fully. It is clear, however, that of all the scientists after Nichols with whom he worked, Sherburne Wesley Burnham and Edward Emerson Barnard at Yerkes influenced him the most. Their world-wide reputations even before they joined Hale in the grand adventure of putting the great forty-inch refractor to work, their notable personal qualities and their utter devotion to the study of nature by accumulating accurate first hand observations, unbiased by pre-conceived theories or assumptions, literally fired the enthusiastic, energetic, young man. The writer came under the same spell only a few years later and knows how determinative the result can be.

When Fox became the head of Dearborn Observatory in 1909, it was natural that he should continue the tradition of the previous director, George Washington Hough, by using the filar micrometer with the famous eighteen and one-half inch refractor, with which the incredibly dense companion to Sirius was first seen. With the career and personality of Burnham burned into his mind, he set out on a program of observation and discovery of double stars. He published the results in Volume I (1915) and Volume II (1925) of the *Annals of the Dearborn Observatory,* which he started. This represents an average of about four complete observations on separate nights of some 4200 double and multiple stars, including 102 discovered by him in the course of his work. Even when he sandwiched other investigations into the observatory program, he still kept up his work with double stars. In fact, from 1937 up to the time when he resumed active status in the army in 1942, he used the telescope on many a clear night for this purpose, whether the temperature in the dome was summerlike or hovering near zero.

After replacing the old Clark mounting with its quaint mahogany tube and long-armed counterweights (now on exhibit at the Adler Museum) by a modern Warner and Swasey mounting in 1911, Fox at once set about preparing for a program of photographic stellar parallaxes. The first plate was taken on May 8, 1912. When Schlesinger in 1914 initiated the coöperative parallax program of the "Big Seven" observatories, Dearborn was one of the seven. He had many loyal assistants, but many delaying events intervened and not until 1935 did he publish this work as Volume III of the Annals. It contained the parallaxes of 197 stars, several of which were doubles, for which separate determinations of distance were made. He was an unusually skillful and resourceful observer. At Yerkes he had taken over Schlesinger's observing program for stellar parallaxes and was familiar with the exacting conditions which must be met in order to get accurate results in this difficult field of astronomy.

Fox's association with Hale at Yerkes led him to undertake another massive study—The Rotation of the Sun, from measurements of the

positions of calcium flocculi, on plates taken with the powerful Rumford spectroheliograph used with the forty-inch refractor. In all, 285 plates taken between August 6, 1903, and November 27, 1908, were used. During 1911 and 1912, he made numerous trips to Yerkes from Dearborn to finish the measurements. The work was finally published from Yerkes in 1921. It is one of the best solutions of this important and complicated problem ever made.

At Yerkes he had become familiar with the stellar slit-spectrograph and its use. He there initiated the use of the Hartmann spectro-comparator for measuring the changes in radial velocity of a spectrographic binary. One good spectrogram would be taken for a standard (later to be measured on a conventional measuring engine and reduced for actual velocity) and all the rest measured differentially.

At Dearborn he early designed and had constructed a spectrograph. Its use was delayed by his preoccupation with double stars, the initiation of the parallax program, and the disruption due to the first world war. By this time the great reflectors had taken care of the bright stars which he could observe, and therefore, no real stress was put upon this program.

Fox made two journeys to observe total eclipses of the sun. On Catalina Island on September 10, 1923, we were clouded out completely. After daylight came on we all stood around our apparatus and looked glum. The first cloudy day in forty had nullified all of our careful preparations. Fox broke the tension by ordering us all to make a group for the photographer and leading in singing over and over again a song, then in vogue, "Yes, we have no bananas, We have no bananas today."

On August 31, 1932, we had better luck and Fox got his observations from a station in Vermont.

He published relatively few short papers. As we have seen, his efforts were dedicated throughout most of his career to massive programs of observation, which have in the past and which must, to a degree, in the future constitute the backbone of observatory programs.

Like his great inspirers, Burnham and Barnard, Fox loved to observe the heavens with large telescopes. To all of them astronomical observing had some of the elements of a sacrament, to be savoured whenever and as long as the stars were visible.

Fox's record of activities and accomplishments, given above, marks him as unusually versatile and brilliant. His mind was clear and he dealt constructively and creatively with all of the many and varied projects which he undertook. He was courageous in the arts and businesses of peace, as he was brave on the field of battle and effective as an officer in time of war. Many an officer, who had served under or with him, has gone out of his way to express to the writer the admiration and affection he felt for Fox. They speak of his strictness and his broad knowledge of military strategy and organization, but always they

emphasize his thoughtfulness of and fairness to his men. He was an excellent teacher and a leading member of the faculty of Northwestern.

His interest in music and skill as a performer with the violin and 'cello were well known to his friends. Fewer people know that he wrote words and music for a considerable number of songs, both in English and in French; that he painted, made pen and ink pictures as well as a number of etchings.

Fox brought back with him from the Philippines a 'cello which most of us remember. He played it with virtuosity, and when some of us at Yerkes noticed that the 'cello had become slightly unglued at the back, he would laugh and say that he needed that circumstance as an alibi. In Evanston the instrument was repaired and both he and Mrs. Fox, who is an accomplished lyric soprano as well as a violinist, entered actively into the musical life of the city.

During one of the writer's visits to Evanston from Yerkes, Fox took him over to the nearby Patten Gymnasium where we alternated for a while at the big pipe organ. Mrs. Fox relates that at times he would go there after finishing his observing for the night and play to the vast dark spaces of the gymnasium before retiring. On one occasion when he was playing, a new colored watchman came by in the small hours of the night and was scared stiff upon hearing the organ speaking from the big dark building.

Fox was physically very active and much interested in all forms of athletics. He would take one golf stick and beat an ordinary dub who carried a whole bagful of them. On one occasion at Yerkes he challenged the writer to a hundred yard dash. He was halfway there before his non-sprinting friend was well started.

One autumn night in 1942, he came to the dome where the writer was making a long exposure with the prismatic camera. He was in uniform and the conversation turned to the question of physical fitness. He got down on all fours on the floor and repeatedly threw himself off the floor completely and clapped his hands at the moment when neither hands nor toes touched it, remarking afterwards, that all of his officers had to be able to do likewise. The writer tried to imitate him and ended by falling in a heap, but took the opportunity of telling the colonel that not only was this performance undignified but also hard on the cardiovascular system of a seasoned officer of the United States Army. In reply, he growled in military fashion, "Fellow, you're getting soft."

Dr. and Mrs. Fox took great pride in their children. Stephen is with the Bethlehem Steel Company. Bertrand, professor of economics at Williams College, is now with the War Production Board in Washington. Gertrude is a doctor specializing in diseases of the chest at Glendale, California. Robert is now Captain in the Medical Corps on active duty in Europe.

Philip Fox's career was varied and colorful. Even the outward circumstances of it make it unusual, notable, and inspiring. Many of us

have marvelled at the rich inner resources of a colleague who could make for himself so many interesting avenues for self-expression. After thirty-seven years of intermittent association with him, the writer, however, feels that in our hearts it is the friendly, whimsical, generous spirit of the man, which will forever endear to us the memory of Philip Fox.

DEARBORN OBSERVATORY, EVANSTON, ILLINOIS, SEPTEMBER 19, 1944.

The Orbits of Comets*

By JULIE M. VINTER HANSEN

It is a deplorable fact that the superstitious fears with which comets were viewed in antiquity and the Middle Ages, combined with the Aristotelian hypothesis that they are phenomena of the upper atmosphere, resulted in the neglect of making serious observations of these objects. Fotheringham, in 1919, put forward the idea that a bright comet seen in 134 B.C. led Hipparchus to make his star catalogue, while it is generally believed that the impulse came from the appearance of a bright new star. If, however, astronomers in antiquity had an idea that comets are celestial objects worthy of observation, it is strange that Ptolemy in his *Almagest* did not mention them. Anyway the Aristotelian ideas about the construction of the universe dominated the western world for centuries, and the few records of positions of older comets are mostly of Chinese and Japanese origin. Not that these Oriental countries did not suffer from similar superstitions as did the Occident, but they associated the appearance of comets with their religion and their dynasties and thought it of importance to follow the path of a comet across the sky.

The distinction of being the first to prove that comets are celestial objects goes to Tycho Brahe. Through careful observations of a comet, seen in 1577, he showed that it must be situated far beyond the Moon and consequently far outside our atmosphere. Later he confirmed his views by observations of six other comets. His authority was so great that his views were immediately accepted. Kepler, who had solved the problem of the planetary orbits so successfully, did not draw similar conclusions about comets. However, he suggested the hypothesis, quite visionary for his time, that the formation of cometary tails was due to the pressure of sunlight, a theory that was proved to be correct in recent times through the investigations of Maxwell, Lebedew, and others. Kepler studied two comets, seen in 1607 and 1618, and thought that they moved in straight lines. In the latter part of the 17th century several men, for instance the Italian Borelli and the German village vicar Dörffel, expressed the opinion that comets move in parabolic

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orbits, but neither was able to explain why it should be so. The explanation came in 1687 when Newton published his law of gravitation, according to which bodies in the solar system move around the Sun in conic sections with the Sun in one of the foci. Newton himself devised a graphic method for the determination of the orbit of a comet and successfully applied it to the comet of 1680.

The next step forward was made by Newton's contemporary, Halley, who computed orbits for 24 comets, for which he had observations, made in the preceding two centuries. In the course of this investigation he discovered that three of the orbits, those for comets seen in 1531, 1607, and 1682, were so similar that they belonged probably to the same object. Thus the first periodic comet was found, which later was appropriately named in Halley's honor.

In the latter part of the 18th century, famous mathematicians and astronomers, such as Euler, Lambert, Lagrange, Laplace, and Olbers, used their skill in devising methods for the determination of parabolic orbits from three observations of a comet. Gauss, on the other hand, in the beginning of the 19th century, solved the general problem of determining orbits without any assumption regarding the eccentricity, and Encke introduced some practical improvements in the Gaussian method.

The methods developed by these men of genius are still the basis for all orbit computation. The three methods used most are the ones of Olbers, Gauss-Encke, and Laplace. In the course of time, simplifications and short-cuts have been introduced by a number of astronomers, among whom may be noted: B. Strömgren and Banachiewicz (Olbers' method), Veithen and Merton (Gauss-Encke's), and Harzer and Leuschner (Laplace's). Moreover, in the present century, with the great development in computing machines, much work has been done in adapting the original formulae, which were derived for logarithmic calculations, for use with modern machines. Which method is preferable is not easy to decide. The preferences seem to be mainly of a geographical nature; the Europeans generally use the methods given by Olbers and Gauss-Encke with the modern simplifications, while some Americans prefer the Laplacean method, as adapted by Leuschner.

Orbit computation and even the somewhat tedious process of computing the perturbations due to the major planets over a long period of years cannot be said to present any great problem today; except in very difficult cases it is a matter only of diligence, accuracy, and patience. Even the length of time required for these often extensive computations has been greatly reduced by the use of excellent, modern electric computing machines and the cleverly devised auxiliary tables which are now in existence. Of the latter may be mentioned the two volumes of "Planetary Co-ordinates" (1900-1960), planned by Dr. L. J. Comrie and published by the *British Nautical Almanac* Office.

The procedure, when a comet is discovered, has now been systema-

tized. Up to the latter part of the 19th century, the news concerning astronomical discoveries was transmitted in a haphazard way by letters and by subsequent publication in scientific journals, though the lack of an efficient method of news distribution was keenly felt. The discovery of the magnificent comet of September, 1882, brought matters to a crisis, and a bureau for astronomical telegrams was established soon afterwards in the German town of Kiel. This service was immediately patronized by a number of subscribers and has existed ever since. In recent years it has been removed to the Astronomisches Rechen-Institut in Berlin-Dahlem. The duty of the bureau was not only to distribute the news of the discovery of comets, but also to provide information concerning their preliminary orbits. The difficulty in international communications, arising from the first world war, led to the establishment of another central bureau in Brussels, Belgium, which in 1922, was moved to Copenhagen, Denmark. Even in the present debacle, this bureau, under the leadership of E. Strömgren, has succeeded in obtaining permission to send code telegrams to its subscribers, via Lund, Sweden. The Harvard College Observatory in Cambridge, Massachusetts, serves as a central station for the Western Hemisphere. A considerable number of astronomers, both professional and amateur, who are not connected with the bureaus assist in making orbit computations; for instance many orbits and ephemerides have been issued from the Students' Observatory of the University of California in Berkeley, and from the Comet Section of the British Astronomical Association in London, England. The definitive orbits of comets and predictions of their re-appearance are generally not provided by the bureaus but by individual astronomers, who volunteer to do this work. An extensive investigation of this sort was done, for instance, by Cowell and Crommelin in connection with the reappearance of Halley's Comet in 1909-10.

Most of the computed orbits are very elongated ellipses and so nearly parabolic, that a parabola satisfies the observations with sufficient accuracy to safeguard against the loss of the comet. In some cases, however, the orbits show pronounced ellipticity, and in other, still fewer, cases the observations can be satisfied only by a hyperbola. If a comet moves in a pronounced ellipse, it belongs to the class of comets called short-period comets. A list of members of this class is given in the accompanying table. A comet which is found to move in an ellipse is, however, not immediately admitted into this class. An orbit based on observations made at only one perihelion passage is generally rather uncertain, so that the comet is not included in the list before it has been observed at a second apparition and found to be near the predicted place. The list has at present 37 members, which is a small number compared with the many hundreds of comets that have been observed, and the many thousands that, no doubt, travel around the Sun, but are too unfavorably situated to be observed. It is obvious that we are able

to discover only those that, near their perihelion passage, are close enough for us to see them; there are, without a doubt, thousands and thousands of comets, some of them very bright, that we are never able to find, because their perihelion distances are so great that we cannot detect them even with the largest telescopes.

TABLE 1

SHORT-PERIOD COMETS

Comet	Discovered	Last seen	Period Years
Encke	1818	1941	3.3
Grigg-Skjellerup	1902	1942	5.0
Tempel II	1873	1930	5.2
Neujmin II	1916	1927	5.4
Brorson I	1846	1879	5.5
Tempel III-L. Swift	1869	1908	5.7
de Vico-E. Swift	1844	1894	5.9
Tempel I	1867	1879	6.0
Pons-Winnecke	1858	1939	6.0
Schwassmann-Wachmann II	1929	1941	6.4
Forbes	1929	1942	6.4
Perrine I	1896	1922	6.5
Kopff	1906	1939	6.6
Giacobini-Zinner	1900	1939	6.6
Biela	1826	1852	6.6
d'Arrest	1851	1943	6.6
Daniel	1909	1943	6.8
Finlay	1886	1926	6.9
Holmes	1892	1906	6.9
Borrelly	1905	1932	6.9
Brooks II	1889	1939	6.9
Reinmuth	1928	1935	7.2
Faye	1843	1939	7.3
Whipple	1933	1940	7.5
Schaumasse	1911	1944	8.0
Wolf I	1884	1942	8.3
Comas y Solá	1926	1943	8.5
Gale	1927	1938	11.0
Tuttle I	1858	1939	13.5
Schwassman-Wachmann I	1927	seen every year	16.3
Neujmin I	1913	1931	17.7
Pons-Forbes	1818	1928	28.7
Westphal	1852	1913	61.7
Brorson II-Metcalf	1847	1919	69.1
Pons-Brooks	1812	1884	71.6
Olbers	1815	1887	72.7
Halley	....	1910	76.0

It may happen that a short-period comet which has been seen at several apparitions may fail to reappear at a predicted time. This fact may be due either to physical changes within the comet itself or to an insufficiently accurate determination of its orbit. Biela's Comet is a striking example of the first case. It was discovered in 1826, and in 1845 split up into two parts, which were still visible at the next appearance in 1852 but have never been seen since, though the comet was replaced by fine meteor displays in 1872, 1885, and 1892. Another example

is Holmes' Comet, which faded considerably during the year in which it was discovered (1892), appeared very faint in 1899 and 1906, and has not been found since.

The prediction of the reappearance of a periodic comet requires an extensive piece of computation, since the perturbations due to the major planets, at least those due to Jupiter and Saturn, have to be taken into account, and in very accurate computations also those of other planets near which the comet may happen to pass in its journey around the Sun. Omission of the calculation of perturbations, or insufficient computation of them, may lead to the comet's escaping notice at its next perihelion passage, since the attraction of a major planet may change a cometary orbit considerably. How much the influence of a planet can disturb the path of a comet is shown in the case of Comet Brooks II, which was discovered in 1889. This comet had no less than three faint companions, all of which moved in the same plane as the main comet, and which may have split off from the parent body. Chandler, by computing the path of the comet backward through the preceding years, showed that the comet in 1886 had experienced a very close approach to Jupiter, when the separation of the parts may have taken place. Furthermore, computations showed that the comet approached Jupiter at a moderate speed, which would have taken it around the Sun in about 29 years, but that on account of the attraction of Jupiter the angular velocity of the comet was sufficiently increased to cause it to make this journey in its present period of 6.9 years.

The first object on the list is Encke's Comet. Encke was not its discoverer, but he computed its orbit for many years, and this orbit proved to have puzzling characteristics. Both Encke and other competent computers found that the comet in each revolution arrived at perihelion a couple of hours before it was due there. Encke explained this peculiarity as a consequence of the comet's having passed through a resisting medium. At first sight it seems anomalous that the effect of a resisting medium is to make the body move faster and therefore arrive earlier than the predicted time, but this resistance produces a decrease in the dimensions of the orbit and hence a shorter period. Later, around the turn of the century, this problem was investigated by the astronomers at Pulkowa, Russia, especially by Backlund, who showed that the shortening of the period does not take place uniformly. Accordingly he did not favor the idea of a resisting medium, but thought that the variable acceleration might be due to swarms of meteorites near which the comet passed at the time of perihelion. Since no other known comet shows a similar decrease in period, one may at least conclude that the resisting medium does not extend throughout the solar system. Comet Encke comes closer to the Sun than any other short-period comet, in fact closer than the planet Mercury, and a possible explanation of the phenomenon might be that such a medium exists in the immediate neighborhood of the Sun, a medium that may be connected with another

phenomenon, namely the zodiacal light. The very accurate orbital elements that have resulted from all these investigations have been used for quite another purpose by Backlund. Since the perihelion point of the comet's orbit is situated inside the orbit of Mercury, the comet will occasionally pass close to this planet and the deviations of the observations of the comet from the computed positions will be due to the attraction of Mercury. From the size of the deviations we may arrive at least at an approximate value of the mass of Mercury. Backlund found that the mass was very small, about 10^{-7} of the Sun's mass.

An interesting short-period comet was found in 1927 by Schwassmann and Wachmann at the Hamburg Observatory. It has a period of 16.3 years, but its eccentricity is so small that the orbit is nearly circular, and, though the comet at all times is rather far away from the Sun (its minimum distance is 5.5 astronomical units, which is greater than the mean distance of Jupiter), it has been possible to observe it all the way around the Sun; this situation is unique for a comet. The inclination of the orbit to the plane of the ecliptic is rather small, and the orbit shows more resemblance to that of a planet than to that of a comet. In 1943, Miss Oterma in Finland found a comet, which also appears to have an orbit similar to that of a planet. This orbit has a small inclination and eccentricity and is located between the orbits of Mars and Jupiter; so there is a possibility of following this comet throughout a whole revolution. The period is about 8 years, but, as the comet has been seen at only one perihelion passage, it has not been included in the accompanying list of short-period comets.

It has been customary to group the short-period comets into four families, as indicated in the list,[1] and to associate them with the four major planets, Jupiter, Saturn, Uranus, and Neptune. The basis for this grouping is the fact that the aphelia of these comets fall in the vicinity of the orbits of the forenamed planets, the supposition being that these heavy planets have been able to capture the light-weight comets which happened to come near them, and thus to change their orbits into their present form. Investigations by H. N. Russell, however, show that, except for the Jupiter family, there is no real foundation for such a grouping. As is seen from the list, the Jupiter family is very numerous. It comprises all the comets with very short periods up to 9 years. The inclination of their orbital planes to the plane of the ecliptic is small like that of the minor planets, and the comets themselves are generally inconspicuous objects with little or no indication of a tail.

The term "comet family" must not be confounded with the expression "comet group." By the latter term is meant comets with orbits that coincide at least in the part that is near the Sun. The most famous of these comet groups is the one that consists of the comets of 1668, 1843, 1880, 1882, and 1887. Though they move in very similar orbits,

[1] The place of Comet Schwassmann-Wachmann I in this grouping is uncertain.

computations by Kreutz have shown that they cannot be the same comet. They all pass close to the Sun; *e.g.*, the comet of 1843 came within 80,000 miles of the Sun's surface. The transit of the great comet of 1882 over the solar disk was carefully observed; the comet could be followed right up to the edge of the Sun, but, during the transit, no trace of its was visible. The comet not only passed across the solar disk but turned and passed behind the Sun. The whole journey, from the disappearance of the comet in front of the Sun to its reappearance from behind, took, according to computations, only about 5½ hours, and the comet attained a maximum speed of 300 miles per second. After this hectic experience, the comet split up into four parts, for which Kreutz found the periods 664, 769, 875, and 959 years, respectively. The explanation of a comet group is that, at some time far back in the past, a very large comet split up into several parts, perhaps more than once, and that the parts went on their ways, practically in the same orbit as the parent comet.

As mentioned previously, some of the orbits turn out to be hyperbolic, even if not strongly so. E. Strömgren has studied these hyperbolic orbits, together with a few elliptic ones, of which the eccentricity was so close to unity that the ellipticity might be considered doubtful. In each case the comet was traced backward in its orbit through computation; the perturbations that the comet suffered from the major planets were taken into account, and the computations were carried so far back that the comet was well outside the sphere of influence of any of the planets. It was then found that, within the accuracy of the computations, all the hyperbolic orbits had turned into ellipses and the slightly elliptic orbits had become more elliptical. These investigations seem to indicate thus that all the comets, which we have observed, moved initially in closed orbits, and so must have originated within the solar system. Whether they will continue to belong to our system is a question. A comet that moves in a hyperbolic orbit, will certainly leave the solar system, unless, on its way out, its velocity is sufficiently retarded through the attraction of one or more of the major planets. Fayet investigated the probability of such retardations and found, that, on the outward journey, these were more likely to occur than accelerations. Nevertheless, some of the comets may escape.

The orbits of comets have been examined statistically in the hope that the existence of some common traits might furnish a clue as to the probable origin of these mysterious objects. Some regularities were found, to wit: small perihelion distances (except in the case of Comet Schwassmann-Wachmann I these were all below 5 astronomical units); more small orbital inclinations than were theoretically expected; and two maxima in the distribution of perihelia, near the points of intersection between the galactic plane and the plane of the ecliptic. It will be obvious, however, that the comets we observe are not distributed at random, but form a selected group, determined by the position of the

Earth's orbit in the solar system. If we had been situated as far away from the Sun as is Neptune, we should no doubt have discovered comets with much larger perihelion distances. Moreover, comets whose orbits lie close to the plane of the ecliptic will have a much longer period of visibility for us than those with large orbital inclinations, and so these have a greater possibility of being discovered. These two apparent regularities therefore tell us nothing about the origin of comets. The third characteristic is more puzzling. Holetschek, from an investigation of 409 orbits, came to the conclusion that this regularity also is a simple consequence of our position in the solar system. Oppenheim found by a theoretical discussion of available data that, while the periodic comets (those having periods up to 1000 years) favor the plane of the ecliptic, comets in nearly parabolic orbits favor the galactic plane. Bobrovnikoff, on the basis of this evidence, combined with that from his own investigations of the rate of disintegration of comets, proposed the hypothesis that comets have not always belonged to our solar system but that the Sun, on its journey through space, picked them up perhaps a million years ago, when it was only about 70 light years from the region of the Orion nebulosities.

It would be natural to compare the orbits of comets with those of minor planets. As far as the short-period comets are concerned, there is no real difference. The comets move generally in more elongated orbits than the planetoids, but there is one minor planet, 944 Hidalgo, which, at its aphelion, nearly reaches the distance of Saturn, and so moves in a sort of cometary orbit, while Comet Schwassmann-Wachmann I and Comet Oterma (1943 *a*) move in typically planetary orbits. This group of comets—except for Halley's Comet—all show direct motion just like the planetoids. Comet orbits generally have larger inclinations than planetary orbits, but the most striking difference is that, while we know of no minor planet with retrograde motion, comets favor direct and retrograde motion almost equally. This circumstance has led to the hypothesis (see E. Strömgren and B. Strömgren: "Lehrbuch der Astronomie," p. 321, 1933) that the comets were formed in the outer parts of the solar system and at such an early stage of its evolution that the system had not yet attained a uniform direction of orbital revolution, while the planets and planetoids were formed at a much later period in the history of our system. This conclusion is in direct contradiction to that of Bobrovnikoff, that the comets are young bodies compared with the planets. At present it must be said that no really satisfactory hypothesis has been put forward as to the age and origin of comets. It seems fairly certain that they are not stray visitors from the outside world, paying us a short call, but that they are *bona fide* members of our solar system, whether formed from the same nebulosity as was this system or from nebulous material that the Sun appropriated in its journey through space.

Though our knowledge about the physical constitution of comets

must come mainly from astrophysical investigations, their orbits can supply some information. A computed orbit provides us with the distance of the comet at any specific time and, from that and the angular dimensions of the comet, we can compute the linear dimensions. These are often enormous. The diameter of the head, which varies with the comet's distance from the Sun, is, on the average, according to Holetschek, 80,000 miles, but in some instances the diameter reaches a million miles. The nuclei, even of large comets, are comparatively small, being generally only some hundred miles in diameter, though Halley's Comet in April, 1910, is reported to have had a nucleus 6,400 miles in diameter. The length of the tails, for comets visible to the naked eye, falls between 5 million and 150 million miles, but varies of course from one comet to another and also for each one, with its distance from the Sun. Though the dimensions of comets are so great, their masses are very small. It has been mentioned how greatly the cometary orbits can be changed by a near approach of a comet to a major planet, but, on the other hand, no appreciable change has ever been observed in the orbit of a planet as a result of an approach of this kind. From this fact an upper limit for the mass of various comets may be calculated, and it is found that it is below 1/10,000 of the Earth's mass, and that probably even a fair-sized comet may have a mass less than one-millionth that of the Earth. The density of a comet's head and, still more, of its tail must accordingly be very small. This result agrees with the observational fact that at transits across the Sun no trace of a comet has been visible. Furthermore, stars have often been observed through the heads of comets. H. N. Russell gives for the mean density of an average comet the figure 1/230,000 of the density of air at the Earth's surface; in the tails the material must be vastly more rarefied.

These considerations do not tell us anything about the chemical composition of this rarefied material, but even here the orbits can yield some suggestion. Through computations, the close connection between comets and swarms of meteorites has been proved. Some of our best-known meteoritic swarms follow orbits that closely coincide with those of observed comets, so that it is safe to assume that the meteorites are split-off parts or remnants of the comets in question. But in that case meteorites give us information about the elements of which the comets are composed. Meteorites consist of nuggets of iron, nickel, and stone (mainly silicon and magnesium oxides), and when they are heated in a vacuum occluded gases like nitrogen (N_2), methane (CH_4), and carbon dioxide (CO_2) are liberated. It is interesting to see whether the existence of these materials in comets is confirmed by spectroscopic evidence. The spectra of comets consist partly of a reflected solar spectrum, which is to be expected, and, partly, of an emission spectrum with lines and bands. This emission spectrum for quite a while offered considerable difficulties to all attempts at interpretation, but in recent years it has finally yielded to analysis through the efforts mainly of

Wurm, Swings, McKellar, Herzberg, and Bobrovnikoff. The following molecules have been identified in comets:

OH, NH, CN, CH_2, CH, CH^+, C_2, NH_2, CO^+, N_2^+, and probably OH^+;

these are all compounds that would be reasonably expected from the gases found in meteorites. Moreover, research seems to prove that these gases are made luminous through fluorescence, produced by the Sun's radiation. Older observations had shown the existence of sodium (Na), and, in one isolated case the lines of iron were observed for a very short time, in the spectrum of a comet, when it was very close to the Sun.

While it is true that cometary research has reached the point today where the classical astronomical field of celestial mechanics offers few if any new problems of much importance, it would be incorrect to conclude that there is not still much work to be done. On the average, 2 or 3 new comets are found every year, and for them orbits will have to be derived. Then there is the group of short-period comets which must be continually followed. Since Barnard, in 1892, discovered the first comet by photography, not many of these rather faint objects have escaped notice, but we have to rely generally on powerful instruments like those at the Lick and Yerkes Observatories for their rediscovery.

The important cometary problems whose solutions are called for at the present time would appear therefore to be of an astrophysical nature. Though much progress has been made recently in this field, many unexplained features still remain: peculiar fluctuations in brightness (*e.g.*, in Comet Schwassmann-Wachmann I), unidentified lines and bands in the extreme red and infrared of the spectrum, and many others. Much observational and theoretical work will have to be completed before a thoroughly satisfactory explanation can be obtained of the peculiar structure of comets, which are so unlike the other members of the solar system.

Lick Observatory, Mt. Hamilton, California, May, 1944.

Increased Accuracy with Ageton's Method

By CHARLES H. SMILEY

The method of navigation due to Commander A. A. Ageton and presented in practical form in H.O. 211 and more recently in his "Manual of Celestial Navigation," amounts essentially to a very convenient method of changing from one system of spherical coördinates to another, as usually employed, from the equator system to the horizon system. For air navigation and for most surface navigation, the method as presented in H.O. 211 is sufficiently accurate. However, the reader's attention is called to a recent paper by Dr. Samuel Herrick.*

*"The Accuracy of Ageton's Method in Celestial Navigation," *Publications of the Astronomical Society of the Pacific*, **56**, 149-155, August, 1944; *U.C.L.A. Astr. Papers*, No. 4.

With appropriate slight modifications, the method can be used in many of the problems of practical astronomy, such as the determination of the heliographic coördinates of sun-spots, the calculation of celestial longitude and latitude from right ascension and declination, the determination of the angle at which the plane of the ecliptic meets the plane of the horizon at a given time and place, and the determination of the longitude and latitude of a point on land. In these problems, and in surface navigation, it is sometimes desirable to obtain greater accuracy than is provided by H.O. 211.

The first suggestion for obtaining increased accuracy would naturally be to use interpolation in H.O. 211. Except for an occasional case, the increase in accuracy from this modification is slight.

One may use the formulas and conventions of H.O. 211, replacing A(x) and B(x) by log sin x and log cos x, respectively, to six or seven decimals. When more than seven-figure accuracy is required, it will usually be simplest to change to computation with natural functions and an electric calculating machine. For the latter purpose, the use of direction-cosine formulas is recommended, since two spherical coördinates can always be determined with precision from three direction cosines. As is frequently pointed out in mathematical textbooks, any method which requires the determination of an angle from its log sine alone (or log cosine alone) will result in the angle being poorly determined when it is near 90° or 270° (for the cosine, when the angle is near 0° or 180°).

In both H.O. 211 and the "Manual of Celestial Navigation," Ageton offers the warning that the accuracy of the method is diminished for values of the local hour angle near 90°; that one should avoid values of K between 87° 30′ and 92° 30′. Since this is an indeterminateness which arises from the method, the question arises as to whether or not there is an easy way to avoid it. From the fundamental formula,

$$\sin h = \sin d \sin L + \cos d \cos L \cos t,$$

it is seen that the value of sin h is not changed if the values of d and L are interchanged. Hence one may use the formulas (in Ageton's notation)

$$\begin{aligned} A(t) + B(L) &= A(R') \\ A(L) - B(R') &= A(K') \\ B(R') + B(K'\,d) &= A(h) \end{aligned}$$

with the usual conventions: K′ given the algebraic sign of L, $K' > 90°$ if $t > 90°$, $K' \sim d$ formed in the usual way. If K′ is sufficiently different from 90°, h is well determined by this method. If K′ also happens to fall near 90°, one should turn to seven-figure logarithms or the electric calculator. Examples are given at the end of this article illustrating the use of this device of interchanging d and L, and the use of logarithms.

To obtain Z when the d-L device is used to determine h, one uses the usual Ageton formulas

$$A(t) + B(d) = A(R)$$
$$A(d) - B(R) = A(K)$$
$$A(R) - B(h) = A(Z).$$

The middle formula may be omitted in cases where the quadrant in which Z is to be placed is known with relative certainty.

One may reasonably ask the question, "How often will K lie between 87° 30′ and 92° 30′?" If one assumes that, area for area, observations are as likely to be made in one section of the sky as in another, the answer is 26 cases in a thousand, the result being practically the same over a fairly wide range of latitudes. However, if one takes into account the fact that observations of celestial bodies at altitudes less than ten degrees are not generally used, and the fact that of the 55 navigation stars listed in the *American Nautical Almanac,* the only star whose declination is numerically greater than 75° is Polaris (and special methods are provided for it), one finds that the probability of K lying between 87° 30′ and 92° 30′ depends to a greater extent on the latitude of the observer, but that, on the average, about 23 cases in a thousand fall in the forbidden range for K—in round figures, one case in forty.

In reality, not all sections of the sky are equally probable as locations for an observed object. The relatively frequent use of the sun, and the practice common on surface vessels of using a noon-altitude for latitude and a morning- or afternoon-shot on the prime vertical for longitude will probably change these figures appreciably.

It is clear that the accuracy of a line of position is a function, not only of the method and tables used but also of the accuracy of the data extracted from the *Nautical Almanac* and of the precision of the observed altitude. There seems to be no point in insisting on great accuracy in a method if one is to use uncertain tabular or observational data. Hence it may be worth while briefly to examine the accuracy of data interpolated from the *Nautical Almanac;* the data in the *Air Almanac* is admittedly approximate.

The sun is used more frequently for navigational purposes than any other single celestial object; on surface vessels perhaps more frequently than all others put together. In the 1944 *American Nautical Almanac,* the Greenwich Hour Angle of the sun is given for every two hours of Greenwich Civil Time, and interpolation tables provide for a change of precisely 30° in GHA every two hours. The tabular differences indicate that this change actually ranges from 29° 59′.3 to 30° 00′.5. This fact is pointed out in the explanation at the back of the 1944 *Nautical Almanac.* Considering the errors arising here from interpolation alone (*i.e.,* ignoring rounding-off errors in tabular values, etc.) it is found that the maximum error in an interpolated GHA of the sun is 0′.7. If the maximum error is determined for each day of the year, the average of these is found to be 0.′28. Taking all times of day and all days of the year into account, the average error from this source is 0′.14. By putting an appropriate interpolation table on each pair of pages (*not,* as

now, always the same one), the maximum error due to interpolation could be reduced to 0′.3 and the average error to 0′.08. A further reduction in the probable error could be made by making the interpolated GHA for the odd hours agree with the true values, rather than the initial even hours as now.

In fairness, it should be pointed out that these errors of interpolation affect only the GHA of the sun, also that an improvement has been made in the interpolation of the GHA of the moon in the 1944 *American Nautical Almanac*.

Examples: The data for the examples below are those of an example offered by Dr. Samuel Herrick, namely: t = 87° 16′, d = +45° 52′, and L = 20° 24′.

By Ageton's Method:

t = 87° 16′	A = 49.4		
d = +45° 52′	B = 15718	A = 14404	
R	A = 15767	B = 14362	B = 14362
		42	
K = +87° 29′			
L = +20° 24′			
K-L = 67° 05′			B = 40961
h = 16° 14′.5			A = 55323

By d-L device:

t = 87° 16′	A = 49.4		
L = 20°24′	B = 2813	A = 45771	
R	A = 2862	B = 45416	B = 45416
		355	
K′= 82° 41′			
d = 45° 52′			
K′-d = 36° 49′			B = 9661
h = 16° 20′.5			A = 55077

By seven-place logarithms:

t = 87° 16′	A = 9.9995056		
d = +45° 52′	B = 9.8428154	A = 9.8559558	
R	A = 9.8423210	B = 9.8564202	B = 9.8564202
		A = 9.9995356	
K = +87° 21′ 03″			
L = +20° 24′			
K-L = 66° 57′ 03″			B = 9.5927549
h = 16° 20′ 17″			A = 9.4491751
or 16° 20′.3			

By seven-place natural functions:

	cosine	sine
t = 87° 16′	.0476876	
d = 45° 52′	.6963305	.7177213
L = 20° 24′	.9372820	.3485720
Products	.0311237	.2501775
h = 16° 20′ 16″.4		.2813012
or 16° 20′.3		

SUMMARY

When greater accuracy is needed than is afforded by Ageton's method as presented in H.O. 211, the use of seven-place logarithms with the standard Ageton forms and conventions is recommended. If even greater accuracy is necessary, one should turn to natural trigonometric functions and a calculating machine.

In cases where the altitude of a celestial body is to be found to within 0'.5 and the usual Ageton routine yields a value of K between 80° and 100°, it is suggested that the values of d and L be interchanged, and the Ageton method be used to determine h. If K' found in this process happens also to lie between 80° and 100°, it is suggested that seven-place logarithms or seven-place natural trigonometric functions be used if it does not seem desirable to discard the sight.

In any event, where great precision is required, the necessary tabular data should be interpolated with care from the *American Ephemeris and Nautical Almanac,* and the observer should make every effort to see that his observations are sufficiently accurate to warrant the extra work.

LADD OBSERVATORY, BROWN UNIVERSITY, PROVIDENCE, RHODE ISLAND, MARCH 1, 1944.

Twenty-Five Years of Soviet Astronomy

By I. A. DIUKOV

Russian astronomy has made great forward strides since the middle of the 19th century mainly through the fundamental work done by Pulkovo Observatory which was founded in 1839. S. Newcomb, one of the greatest American astronomers, called it the "world astronomical metropolis"; Pulkovo has preserved this reputation during the past 25 years. The Catalogue of Absolute Positions prepared at Pulkovo for the epoch 1915.0 was of no little importance in the compilation of the big international catalogues such as B. Boss' General Catalogue and Auwer's Third Fundamental Catalogue (FK3).

In 1928 the Pulkovo Vertical (Ertel's) Circle was moved to a more convenient building and it later became necessary to carry out a series of new observations in order to correlate those made in the old premises. The program of observations made was of stars contained in W. Struve's catalogue. The Pulkovo Catalogues of 1905.0 were also based on these lists while the Pulkovo Catalogue for 1925.0 followed the same lines.

Other work in this line was the general combined catalogue of Right Ascensions and Declinations of 1642 stars compiled by Pulkovo Observatory and Leningrad University. On the proposal of J. C. Kapteyn, a well-known Dutch astronomer, long series of observations of the stars in the "Backlund List" were made by nine of the world's observa-

tories (Pulkovo, Greenwich, Cape of Good Hope, Washington, Paris, Algiers, Uccle, Babelsberg, and Nikolayev). Each star was observed from 70 to 100 times, insuring the greatest accuracy, and the results went into the making of the above-mentioned catalogues.

During this period Pulkovo Observatory also prepared a catalogue of 3,396 stars of the Helsingfors zone, a list of the so-called "intermediate" stars, supplying comparison stars for the whole northern part of the celestial sphere such as are necessary for the revision of the photographic AG-zones.

In addition to the Pulkovo and Nikolayev Observatories the work of compiling star catalogues has been continued by the Moscow Observatory (S. A. Kasakov), Odessa Observatory (I. A. Diukov, P. B. Zimmerman, and others), Kharkov Observatory, Tashkent Observatory, and the Engelhardt Observatory at Kazan (M. A. Grachev, I. A. Diukov).

Of special importance is the catalogue of geodetic stars. The Backlund List already mentioned did not include all the bright stars (up to the sixth magnitude) which are used in geodetic work. In the northern skies (up to —10° declination) there are some 1,334 stars of equal magnitude, the positions of which are less accurately known. Geodesists, therefore, experienced certain difficulties when plotting the coördinates of geographic points. On the initiative of N. V. Zimmerman, the Pulkovo, Moscow, Tashkent, Nikolayev, and Engelhardt Observatories carried out a series of observations on these stars. These same stars had been observed with the transit and vertical circles at Pulkovo so that the coördinates could be deduced with sufficient accuracy for the requirements of the geodesists. This task was accomplished by the late N. V. Zimmerman with that consummate skill which we were accustomed to associate with him. He died during the winter of 1941-1942, the siege winter in Leningrad.

In addition to the work on the catalogues various lines of research were followed, such as, the systematic difference in declination obtained by the Pulkovo and Odessa Observatories, the systematic difference in right ascension discovered by the observatories in the upper and lower culminations, causes of errors of the type in the NFK system, the problem of the 'jump in zenith' in the observations made on right ascensions, systematic differences in the zenith distances of stars by day and by night, the influence of different types of transit circle on the values of right ascensions, the influence of various methods of the absolute determination of the zenith distance of declinations, etc.

A special investigation was made of the errors in the 1° divisions of the limbs of the Moscow, Kiev, Odessa, Kharkov, and Engelhardt meridian circles and in the 10′ divisions of the Pulkovo circle; new methods were worked out for studying tube flexion; very good results were obtained for the equinox correction epoch 1915.0 (N. Idelson).

A marked development in the research work of Soviet astronomers

was the plan which was drawn up for the construction of a fundamental system of faint stars; work on this has already been begun. This problem is being simultaneously developed by foreign astronomers and was discussed at the last congress of the International Astronomical Union. Soviet astronomers treated the subject very elaborately and are still continuing the work. Pulkovo Observatory took the initiative in this huge task and introduced it at the All-Union Astronomical Conference in 1932 when two very interesting papers on the subject were read. After the conference other Soviet observatories were drawn into the work and some very important investigations were made at the Sternberg Astronomical Institute in Moscow where a list of stars for the catalogue was drawn up (M. S. Zverev). A list of extragalactic nebulae was compiled at the Simeis Observatory by G. N. Neujmin; the Engelhardt Observatory succeeded in correlating the faint stars with GC and FK3 (I. A. Diukov); Pulkovo and Tashkent Observatories worked out a method for ascertaining the zero point of right ascensions for the catalogue of faint stars and conducted a series of test observations (F. F. Renz, L. L. Matkevich, A. A. Nemiro) and, lastly, the Leningrad Astronomical Institute of the Academy of Sciences worked out the theory of motion of some of the minor planets selected for the purpose of determining the equinox point and the equator for the catalogue of faint stars.

Systematic observations were begun in 1940; the first stage of the work consisted of observations in accordance with a specially drawn up program to connect the new system of star positions with the FK3 system. The treacherous attack of the fascists interrupted the work of some of our observatories in the western districts of the country but the Tashkent and Engelhardt observatories brought the first part of the program to a successful conclusion and started work on the second part, absolute observations of the principal faint stars.

Soviet astronomy has done good work in the latitude service. As far back as 1915 a new program of observations with the Pulkovo Zenith Telescope was proposed by O. A. Backlund, which consisted of observations of 105 pairs instead of the former 65. This greatly increased the accuracy of the average daily data. This new program also facilitated the solution of certain delicate problems connected with daily latitude variations. In this respect the work of V. R. Berg and S. V. Romanskaya, published in the *Transactions of Pulkovo Observatory*, Vol. LII, is of great interest; the data given were obtained by observations carried out between 1917 and 1929 and form the first part of the extended program of 105 pairs for the zenith telescope. Throughout the periods observations were made on every clear night from dusk till dawn. This first series of observations was intended mainly to study daily latitude variations. The second series of observations was carried out from 1929 to 1940 and was intended for the detailed study of local latitude variations. Unfortunately the talented astronomer V. R. Berg,

who directed these observations, died prematurely during the siege of Leningrad in the winter of 1941-1942. The severe damage which Pulkovo Observatory suffered from bombs and artillery fire and the evacuation of the Observatory prevented the completion of these observations. It will be one of the post-war tasks of Soviet astronomers to study the valuable material which has been accumulated and to arrange similar series of observations at Pulkovo and other latitude stations of the U.S.S.R., first and foremost at Kitab.

The organization of an international latitude station at Kitab on the 39° 8′ parallel may be regarded as an achievement of Soviet astronomy. It may here be noted that Russian astronomy joined the international latitude service by the opening of the Charjui latitude station in prerevolutionary days. The inadequate equipment and lack of funds from the tsarist government, however, coupled with unsatisfactory climatic conditions, greatly hampered the work of the station. It was only persistent work and devotion to science on the part of the astronomers that enabled the Charjui station to obtain any acceptable results. The attitude of the Soviet government has been quite different. Large sums of money were allotted for the organization of a new station; its equipment is on a level with the most up-to-date latitude stations in the world; the staff of astronomers has been increased. Observations were begun in 1930 and have been continued uninterruptedly.

An important forward step in the latitude problem was made when the Poltava Latitude Observatory was organized on the proposal of Professor A. I. Orlov, Member of the Ukrainian Academy of Sciences. There are two bright zenith stars (UMa and Per.) at the Poltava latitude (49° 30′) separated by an interval of $10^h.5$ in right ascension. Highly interesting work was carried out at Poltava on daily latitude variations, the correction of systematic errors in latitude observations with the zenith telecope, etc. The Poltava Observatory was well equipped with modern instruments and was the object of considerable attention on the part of the Ukrainian Academy of Sciences.

The temporary occupation of Poltava by the German fascists interrupted the work but, now that Poltava has been liberated by the Red Army, active preparations are being made to restore the observatory and continue the important work it was doing.

Engelhardt Observatory near Kazan has also been carrying out latitude observations for over 11 years.

Valuable work has been done by Professor A. I. Orlov, member of the Ukrainian Academy of Sciences, on methods of analyzing data provided by observations made with the zenith telescope, the working out of the curve of polar motion, the working out of the geoid figure on the basis of latitude observations, and the establishment of three new latitude stations on the 49° 30′ parallel.

One of the greatest achievements of Soviet astronomy is undoubtedly the organization of the time service. Much of the success is due to

great developments in the field of radio. The first experiments in broadcasting regular time signals were made by the Pulkovo Observatory in 1920. By the time the present war broke out there were seven excellent "time stations" in the U.S.S.R.; two in Moscow and one each at Pulkovo, Leningrad, Tashkent, Kharkov, and Nikolayev Observatories. All of them were equipped with Shortt clocks, Bamberg transit circles, and excellent radio receivers. The question was also raised of organizing two or three time service stations in the eastern part of the U.S.S.R. The organization of time service stations in the eastern districts, however, took place in connection with the evacuation of observatories from the west. The Sternberg State Astronomical Institute in Moscow organized a first-class time service station in Sverdlovsk. The Moscow Central Geodetic Institute organized a similar station at Jambul, in Kazakhstan.

The main task of the time service stations is to determine exact time by astronomical observation, to maintain this time on astronomical clocks, and to make corrections in the time service broadcast by other stations. The effort made by Soviet observatories to improve the time service proved very fruitful, the best results being obtained at Pulkovo Observatory where N. N. Pavlov employed photoelectric methods of recording the transit of stars. Pavlov worked persistently at his theory and by 1939, overcoming all the difficulties that stood in his way, introduced the determination of exact time by the photoelectric recording of star transits. This was the first time this method had been successfully applied anywhere in the world. The method is a great improvement over old ones as it does away with a source of constant error made by the human element in recording observations. The new method promises good results in recording declination and has its applications in other astronomical problems. The Sternberg Astronomical Institute (M. S. Zverev) made good use of the experience in organizing the Moscow time service to set up a considerable improved time service in Sverdlovsk. The first quartz clock in the U.S.S.R. was constructed and put into operation by P. S. Popov at the Central Geodetic Research Institute.

The Kazan Observatory has done very valuable work in observations of the moon; since 1895 observations of the Mosting A crater have been made with a view to studying the form and the rotation of the moon. Forty-nine years of constant observation of the very slight inequalities in the rotation of the moon, these lasting over varying periods, some of them being of long duration, have shown the great value of this work, the importance of which will increase as time goes on. The only attempt at analyzing these observations in the prerevolutionary period was the unsuccessful one made by the astronomer Foelkel at Breslau to whom A. A. Mikhailovsky's data were sent (1895-1905). The observations have since been analyzed by I. V. Belkovich, a promising young Soviet astronomer. Another Kazan astronomer who

has done excellent analytical work is A. A. Yakovkin. He has analyzed three series of observations, those of T. A. Banakhevich (1910-1915) and two of his own (1916-1926 and 1926-1931). Belkovich is at present working on the analysis of his own observations made between 1931 and 1942. Thus all the Kazan observations, with the exception of the first series made by A. V. Krasnov and M. I. Ivanovsky which have not been found, have been analyzed since the revolution, a fact which goes to the credit of Soviet astronomy.

This work has had a number of important results. A. A. Yakovkin discovered that the disc of the moon has not got a circular circumference but is a complicated curve. Yakovkin's first hypothesis is that the southern hemisphere of the moon has an additional layer increasing in thickness from the equator to the pole. This was confirmed by an analysis of published data made by I. Belkovich; the data concerned observations of the occultation of stars by the moon and observations of the moon made with the meridian circle of Washington Observatory. This is a new proof of the value of accurate observation of the occultation of stars by the moon. Soviet astronomers have given considerable attention to these observations.

My brief sketch of the work of Soviet astronomers would not be complete without a few words on photographic astronomy. Soviet astronomers received a very poor inheritance from pre-revolutionary days. It is true there were some enthusiasts such as S. K. Kostinsky, P. K. Sternberg, and others who made numerous photographs of various sections of the sky; their efforts, however, were not made systematically and the photographs were insufficiently analyzed. The astronomers who took the photographs could not afford the time necessary to work over and elaborate the tremendous material they accumulated. Soviet astronomers have made considerable progress in this work. Catalogues of the stars in Kapteyn's selected areas have been published as well as an extensive catalogue of the northern stars with declinations from 65° to the pole.

Soviet photographic astronomy is now participating in the compilation of the catalogue of faint stars. Soviet astrographers are also taking part in this work so that a successful outcome is to be expected.

The Soviet government provides all the necessary conditions for fruitful scientific work and Soviet scientists make every effort to justify the solicitude of the government and of Marshal J. Stalin.

KAZAN UNIVERSITY.

Professor Otto Struve Receives Gold Medal Award

As already announced, Dr. Otto Struve, director of the Yerkes and McDonald Observatories, is the recipient this year of the Gold Medal awarded by the Royal Astronomical Society, London.

Because of the interest and justifiable pride felt by the astronomers in the United States as a result of this award, and because of the significant astronomical history set forth by Professor E. A. Milne, president of the Royal Astronomical Society, in making the award on April 14, 1944, we reprint here a part of Professor Milne's address as it appeared in *Monthly Notices*, Vol. 104, No. 2, 1944. EDITOR.

"The Council has awarded the Gold Medal of the Society to Professor Otto Struve for his work on the observation and interpretation of the spectra of stars and nebulae.

"It will be my duty and privilege shortly to lay before you the grounds for this award. But before doing so I should like to remind the Society of what an historic occasion this is, historic in the annals of the Society and historic in the annals of the Struve family. For this is the fourth time that a representative of the astronomically minded family of the Struve's has been awarded the Society's Gold Medal—four times in a hundred and eighteen years, or once in each generation.

"My predecessors in this office, when presenting Gold Medals to members of the Struve family, have begun by addressing you on the grounds of the award, leaving to the end of their discourses the remarkable family connection of the Struve's with this award. But the present occasion is so notable that I ask to be allowed to dwell on this aspect of the matter first. I should mention that your Council in making this award was totally uninfluenced by the glamour that surrounds the name Struve in the history of astronomy. The present recipient was selected in fair and indeed severe competition with other names, severe not only in these war-time conditions, where the choice of medallist is partly limited by questions of nationality, but severe also by any absolute standard. It is to the glory of our subject that there has never been any shortage of names of the standard of this, the highest award in the Society's gift, and it was partly because of the probable future abundance of astronomers worthy of receiving the Medal that your Council decided to continue the restoration of its normal practice of awarding the Gold Medal at the Annual General Meeting of the Society—a change from earlier war-time procedure fittingly initiated by the award last year to the Astronomer Royal. Professor Otto Struve, I repeat, has earned this distinction in his proper right, by the overwhelming significance and value of his brilliant observational and interpretational work in stellar and nebular spectroscopy. I shall come to this later.

First, however, I want to set his contributions in their historical setting, by mentioning briefly the astronomical contributions of his distinguished forbears so far as they concern this Society.

"Science in the last century or two has given us many examples of families in which son has followed father with a like distinction. In physics this country has given us the Strutts, the Thomsons and the Braggs. France has produced the Curies, mother and daughter. In meteorology the elder and the younger Bjerknes are famous. Coming nearer to our own subject, the notable and continuously able family of Darwin has given to astronomy a son perpetuated in our George Darwin lectureship, whose son in turn we are happy to number now amongst our Fellows. In astronomy, amongst contemporary names we can claim the Plasketts, and amongst the giants of old the Herschels. But perhaps no family can vie with the Struve family in its devoted pursuit of, and its achieved distinction in, astronomy.

"Wilhelm Struve, great-grandfather of our Medallist, was born in 1793 and died in 1864. After working first at Dorpat, he founded in 1839 the Pulkova Observatory, which he directed for nineteen years. He was awarded the Gold Medal of the Royal Astronomical Society in 1826, in the early days of the Society, for his work in discovering and measuring double stars. It was on April 14 of that year—note the date—that J. F. W. Herschel, acting as proxy for Wilhelm Struve, received the Gold Medal at the hands of Francis Baily, the then President; Gold Medals were also presented in their own right to J. F. W. Herschel and to his collaborator J. South. The work of Wilhelm Struve had been accomplished at Dorpat, with the aid of a telescope made by Fraunhofer. Double stars were then a study of recent date, the subject having been opened up by Sir William Herschel, who, beginning with a knowledge of only four double stars, went on to determine a great many cases of relative orbital motion in close pairs. His work had been continued by his son and by South, working together, and independently by Wilhelm Struve. I have already referred to the Herschels as giants of old, and this bracketing of their names with that of Wilhelm Struve shows that he too is to be regarded as amongst the giants of old. Baily concluded his address of presentation to Wilhelm Struve, even more prophetically than he can have anticipated, by saying: "His services in the cause of science assure us that the name of Struve will be imperishable in the annals of astronomy."

"The grandfather of our Medallist was also an Otto Struve. The son of Wilhelm, he was born in 1819 and died on 1905 April 14. He followed his father in the directorship of the Pulkova Observatory, though not immediately; he directed it from 1862 to 1890. Like his father before him, he won our Gold Medal before becoming Director of Pulkova—the year was 1850, during his father's directorship. The grounds of the award were a paper on "The Determination of the Constant of Precession with regard to the Proper Motion of the Solar Sys-

tem." It had been again Sir William Herschel who, in 1783, first drew attention to the proper motion of the solar system towards the constellation Hercules, by considering the directions of the then available proper motions of the stars. The subject was taken up by Otto Struve the elder, who made use of some 265 double stars and 174 wider pairs observed at Dorpat, together with other stars. From their proper motions between 1755 and his own epoch he isolated the geometrical precessional motion. His great problem was how to correct the observed proper motions for the solar motion, which is of course more important for the nearer stars. Struve attempted to connect distance and magnitude, and, adopting 0".2 as the annual parallax of a star of the first magnitude, found the Sun's annual motion to be 1½ times the radius of the Earth's orbit. This was a very creditable estimate, the true value being about four times the radius of the Earth's orbit. On this occasion, 1850 February 8, the Gold Medal was presented by Airy.

"The third generation in the Struve family to receive the Gold Medal was represented by Hermann Struve, elder son of Otto Struve, grandson of Wilhelm Struve and uncle of our present Medallist. He was born in 1854 and died in 1920. He founded the Berlin-Babelsberg Observatory in 1913. He was awarded the Gold Medal of this Society in 1903 for his work on the satellites of Saturn. This was an arduous and comprehensive performance, involving comparisons of the satellites in pairs made over many years, and a huge labour of arithmetic. He deduced the true position of Saturn's equator, and from the orbits of the satellites themselves went on to determine the changes in their orbits, and so to the masses of the satellites and the shape of the planet. He confirmed Clerk Maxwell's theoretical work on the smallness of the mass of the rings. H. H. Turner, who presented the Medal on this occasion (1903 February 13) described him as "master of all his weapons, from the 30-inch telescope to the complexities of the gravitational analysis." Turner went on: "It is natural that our thoughts should stray to-day from the present occasion to the past; from the man himself to his father, who was awarded our Medal half a century ago; and to *his* father, who received it a quarter of a century before that. For the third time we welcome the name Struve to our list of honour, and a welcome as cordial awaits an unlimited number of those who in the future may produce work of the same quality as their forefathers. We are glad to think that its value to him will be enhanced by the knowledge that it ranks him with his venerable father [then still living at the age of eighty-four] and his famous grandfather."

"That welcome then hypothetically held out by Turner we extend in actual fact today to the fourth generation, to the great-grandson of Wilhelm Struve, to Otto Struve the second. He has been faithful to his family tradition, and is ranked with his progenitors. *Our* Otto, as I may now call him, is the son of Ludwig Struve, who was the younger brother of Herman Struve and the second son of Otto Struve the first.

Ludwig Struve, it should be recalled, was also an astronomer of reputation: he was Professor of Astronomy in the University of Kharkov, and died in 1920. Thus do we welcome, in 1944, the successor to honours previously bestowed by this Society in 1826, 1850, and 1903.

"Double stars, the solar motion and precession, the Saturnian system —after these three major and representative astronomical themes it is meet and right that the youngest of the Struves should have devoted himself to astrophysics, that younger sister of the classical astronomy. And with no sparing hand; for he has distinguished himself equally in the precision and wealth of his spectroscopic observations, his fertility in the design of new spectrographs, his power of execution of new astrophysical projects, his modernity in his analysis of spectroscopic phenomena, the width and generality of the problems he has selected and attacked, and the brilliance of his solutions of these problems and the bold sweep of his interpretational grasp. Add to this that he has throughout shared in the actual observing and reduction of spectrograms; that he has edited the senior journal in astrophysics and personally reviewed most of recent astrophysical literature in its pages; that he has followed the family tradition in founding a new observatory, but that he has exceeded the family tradition by directing not merely one but simultaneously two great observatories; and lastly that he has inspired and gathered round himself a devoted band of loyal and original-minded co-workers—and we have the parts of an astrophysicist indeed, one who has carried the family fame, in a new subject, to a new continent, and made good.

"I would now remind you that the Gold Medal is awarded for his individual work, some of which I will try to pass in review. To deal with the whole of it would be beyond my time and powers. . ."

The Mapleton Meteorite

By BEN HUR WILSON

"Iowa Adds an Iron to her Collection!"

Among the regions that have been unusually favored in the number and importance of their meteorite visitations, Iowa ranks high as a field for the investigation of such phenomena, for within her borders have occurred four of the most noteworthy "falls" witnessed in modern times. By the frequent appearance of meteors the people of Iowa became accustomed to such phenomena and so educated in respect to their true significance that the passing of a great meteor was no longer viewed with fear and apprehension, but rather with a lively interest and curiosity.

This fact greatly aided scientists in their subsequent investigations carried on within the respective fields, for the purpose of ascertaining such vital information pertaining to them as was desired. The earliest

recorded Iowa meteorite fell in the vicinity of Marion, in Linn County, on February 25, 1847. It attracted considerable attention and comment throughout the scientific world, being one of the very first to be expertly investigated by scientists in the entire Western Hemisphere.

On the evening of February 12, 1875, came the great Amana meteor, which for sheer beauty and brilliance of its pyrotechnic display has seldom been surpassed. The Estherville meteoric shower of May 10, 1879, was in several respects the most remarkable ever seen to occur. Not only was this the largest observed American meteorite, but it was the largest "iron-stone" type whose fall has been witnessed anywhere. Moreover, the principal mass, which weighed four hundred and thirty-one pounds, penetrated the earth farther than any other known until that time.

Then, finally, on May 2, 1890, came the great Forest City shower, which, for the number of individual pieces recovered, almost rivaled its immediate predecessor. Specimens of all of these great "falls," which were witnessed by numerous individuals, may now be found scattered widely, in the cabinets of many of the great museums of the world. Of the above four great "showers" only one, the Estherville, was classed as belonging to the rarer mesosiderite ("iron-stone") type, while each of the Marion, Amana, and Forest City meteorites was classed as the more common ("stoney") variety, known as aerolites.

Now, after a lapse of nearly fifty years, comes a "new deal" in the history of Iowa meteoritics, for on the seventeenth of June, 1939, Mr. Harvey Meevers, a farmer residing a few miles east of Mapleton in Monona County, accidentally found the first "siderite" or "iron" meteorite ever recovered in the state of Iowa. It also was distinctive as being the only one ever found there which was not seen to fall. The circumstances attending its discovery as described by Mr. Meevers are given in the following paragraphs.

At about eleven o'clock in the forenoon of June 17, 1939, he was cultivating corn in the field southeast of his house. Suddenly the plow caught behind a heavy object, which seemed so unusual that he stopped his team and "dug the object out of the ground," for a closer examination. "It seemed heavier than any other stone" he had ever struck before, so he put it on the back of the cultivator for a weight.

Driving in from his work in the late afternoon he took it along with him and, while unloading it, came to the conclusion that "it was a mass of iron," and decided to save it, putting it inside the barn for safe-keeping. After the usual chores he went to the house to wash up for supper. Very soon, however, a severe thunder-storm came up and he remembered the large piece of iron left in the barn. Fearing that it might "draw the lightning," he went out immediately and dragged it out and away to a safe distance from the building.

Eventually, the object was shown to a number of friends and neighbors, and naturally their curiosity concerning its true identity was con-

siderably aroused. Strangely coincident, the current issue of the *National Geographic Magazine* carried an article describing meteorites, by Mr. F. Borrows Colton, which furnished them the important clue needed to solve their problem. This was indeed fortunate, and was probably responsible for the saving of the object to science. Had its true nature not been early recognized, it would doubtless have, sooner or later, been cast aside and eventually lost sight of altogether, as we have reason to believe has been the fate of several other finds made in Iowa throughout the years.

So confident was Meevers of his identification that he soon took it to town and exhibited it in the window of the local bank as a meteorite. The object, it was found, weighed one-hundred eight pounds, and possessed all of the characteristics typical of an iron meteorite, including a dark brown, somewhat rust stained surface, pitted with those peculiar prints known as "thumb marks," which appear as if someone had pressed his thumb at random into a plastic surface which afterwards become indurated by nature.

Its dimensions, taken from careful measurements made at the time, are given as: length, 17½ inches; width, 9⅞ inches; thickness, 6¼ inches. There can be no definite proof as to how long the "iron" may have lain buried in the ground before it was discovered. This period may perhaps have been twenty-five years, or, on the other hand, it may have been several hundred or even thousands of years. There can be no absolute way of knowing. Its appearance, however, particularly its lack of extreme weathering, seemed to indicate a shorter rather than a longer interval.

There also were a number of local people who suspected that it was definitely connected with a certain great "fireball" which went streaking across the sky, at about ten o'clock one evening during the winter of 1915 or 1916. The exact date of this event is uncertain. The concensus seems to be "that the ground was frozen hard at the time, that some people had already retired for the night, and that it was certainly just before the start of World War I." Mr. Meevers, himself, thinks that this occurred on Thanksgiving evening in 1916. Were it of sufficient importance a search of local newspapers files of that period might definitely establish the date.

Be this as it may, this fireball which was observed by a number of people in the vicinity of Mapleton, traveled, apparently, in a "northeasterly direction, giving off a great deal of light, and was followed by a loud explosion." An observer at Emmetsburg, some eighty-five miles northeast of Mapleton, reported that the bright light and explosion took place to the south and west of his point of vantage. If this was actually the meteorite found by Meevers, it is difficult to account for the fact that it buried itself so deeply in the soil as to have eluded detection in a field which must have been plowed and cultivated many times during the intervening twenty-five years, for under such circumstances meteor-

ites usually bounce on striking the frozen ground, rather than penetrate deeply into it. The explosion would also indicate that it must have been broken into several fragments, none other of which has ever been found.

Furthermore, David E. Hadden, a prominent local astronomer of Alta, Iowa, writing in *Popular Astronomy Magazine* (Vol. 25, page 483) describes a brilliant "Detonating Meteor" which went streaking across the western sky, in a southerly direction, at about 9:55 P.M. on the evening of May 31, 1917. At this time of the year the ground would not have been frozen, and as viewed from his geographic position there is a possibility that this event might also have had some bearing upon the "Mapleton Iron," although here again there can be no definite proof.

While on exhibition in Mapleton, a small chip for a sample was sawed off the meteorite with a hack-saw by a local blacksmith. This revealed a bright metallic interior, which confirmed the theory of the local scientists that it was composed principally of iron. No doubt, being somewhat anxious to turn his new possession into cash, Meevers sent the following letter on July 22 to the Field Museum of Natural History (now the *Chicago Natural History Museum*) whose address he had obtained from the article in the *National Geographic Magazine*.

"Gentlemen: I have recently discovered a meteorite on my farm, it is of quite considerable size, weighing 108 pounds. This, I understand, is large as meteorites go.

"I wonder if you would be interested in securing this relic for your museum, and if you would make an offer for the same. I have a small chip I could send in case you would want to analyze same to determine its authenticity. Of course, I would expect to get the sample back again."

In response to this letter, Clifford C. Gregg, Director of the Museum, immediately replied to the effect that they would be glad to examine the sample, and notify him of the results of their findings.

In mailing the "small chip" to the Museum on July 26, Mr. Meevers again showed the utmost confidence in correctness of his identification, saying "I am sure that your report on this sample will be that it is a genuine meteorite and that it will have considerable value as a historical piece as well as conveying some leads which will give additional information which is of interest to geologists and astronomers."

The letter containing the above paragraph, and the "chip" referred to were received by the Museum on the morning of July 28, 1939. An examination was made at once and the sample was immediately pronounced to have come from an iron meteorite. Arrangements were speedily made between Mr. Elmer S. Riggs, who was acting Chief Curator of Geology in the absence of Dr. H. W. Nichols, and the administrative departments of the Museum "for an immediate examination of the meteorite with the view of entering into negotiations for the purchase of the same."

Consequently, on the following day, Mr. Bryant Mather, the associate curator of mineralogy, accompanied by Mr. Warren Raymond, the assistant Register, journeyed to Mapleton, where they visited Mr. Meevers. They were very cordially received and, after assuring themselves of the authenticity of the specimen, negotiations for its purchase were successfully carried on. At first, Mr. Meevers seemed reluctant to consummate a sale on such short notice, as he had apparently written letters to other potential buyers. Only the Field Museum had replied, however, by the time their representative appeared on the scene.

Before he would consent to the sale, it was necessary for him to withdraw from the scene of the negotiations (the back porch) and consult at length with advisers by telephone and with Mrs. Meevers in person in the house. The desirability of having the meteorite preserved in the Mid-West rather than in the East where it would be much more difficult for him and his friends "to come and see it on display" was one of the deciding factors, according to Mr. Mather, which eventually "led him to accept the offer we made and to pick up the five-dollar bills we had been lining up along the edge of the porch," as the negotiations proceeded.

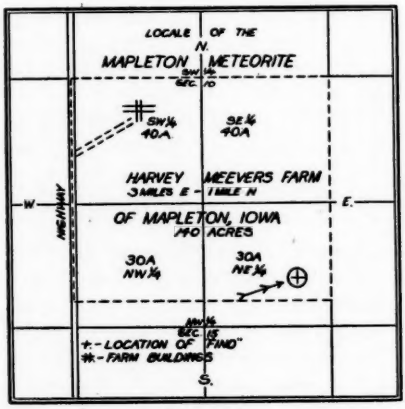

FIGURE 1

Upon the completion of the transaction, Messrs. Mather and Raymond made detailed notes concerning the circumstances of its recovery, and particularly the exact location at which it was found, which proved to be the N.E. ¼, N.W. ¼, Section 15; Township 85 North; Range 42 West; in Cooper township, about three miles East and one mile North of Mapleton, Monona County, Iowa. By careful comparison with available maps, Stanley E. Harris of the Iowa State Geological Survey has determined this position to be 42° 10′ 47″ north latitude, and 95° 43′ 18″ west longitude, this being the location of the center of the 1/16 section.

"It was also agreed" reports Mr. Mather, that, "we would make an effort to have notices of the finding of the meteorite placed in the Mapleton and Sioux City, Iowa, newspapers, to have copies of whatever publicity that might appear sent to him, and, finally, to suggest that he be made a member of the Museum and sent a card entitling him to free admission." It was late in the day when the specimen was carefully placed in Mr. Raymond's car, adieus were said, and the boys set out joyfully for Chicago, where early the next morning the Mapleton meteorite was safely delivered into the permanent care and keeping of the Field Museum of Natural History.

The first brief published notice of the Mapleton meteorite was prepared by Mr. S. K. Roy of the Department of Geology of the Field Museum, appearing under the title "Field Museum Obtains First Iron Meteorite Ever Reported from State of Iowa" in *Field Museum News* for September, 1939, (Vol. 10, No. 9, page 4). The following month, October, 1939, *Rocks and Minerals Magazine* (Vol. 14, No. 10, page 320) also published a brief account, evidently copied from the information given in the Field Museum publication. In both of these articles the name "Mapleton Meteorite," was assigned to the object, which it will doubtless carry on down through history.

FIGURE 2
PHOTOGRAPH OF THE MAPLETON METEORITE
(Courtesy of the Chicago Natural History Museum)

In due time, the museum authorities took up the scientific investigation of their newly acquired treasure, including such matters as chemical composition, specific gravity, internal structure, etc. In determining the latter, it becomes necessary to section (saw) the whole, whereupon the flat surface is first polished very smoothly and then etched by dipping it repeatedly for brief intervals into a weak solution of nitric acid. This brings out into relief, the so-called Widmanstätten figures, thus revealing the internal structure of the meteorite, by which means it is

classified. The Mapleton "iron" proved to be of the type called Medium Octahedrite, which is not at all uncommon, and the width of the Widmanstätten bands are stated as one millimeter.

On the etched slab, the narrow band of alpha iron which usually appears at the surface, indicating the depth of penetration of heat during its passage through the atmosphere, is missing, and the "figures" reach all the way to the crust. There is a suggestion of a narrow band of lighter color about one millimeter in width next to the crust in places, but the figures penetrate through it and it appears to be merely the result of imperfections in the etching.

According to Dr. Nichols, the width of this band where the heat has transformed the beta iron to alpha, at a temperature between 400 and 500 degrees, indicates the depth of penetration from which may be determined some of the circumstances of the fall. "This taken in conjunction with the thinness of the crust, not over 0.25 millimeter, suggests that the meteorite burst at so late a period of its fall that there was not time for any noticeable penetration of heat. If this should be the case there is a chance of a future find of another individual within perhaps ten miles."

The specific gravity of the Mapleton Meteorite, as determined from a small section of same, by a museum technician, was found to be 7.70, and since the entire "iron" appears to be quite homogeneous throughout, we are safe in assuming that this would be practically correct for the specimen taken as a whole. This, we believe, is about the average for "irons" of this type.

Chemical analysis, made in the museum laboratory by Mr. Henry Herpers, the museum chemist, disclosed the following elements present, which are given with their percentages: Iron, 92.16; Nickel, 7.61; Cobalt, 0.036; Copper, 0.003; Carbon, 0.14; Sulphur, 0.01; Phosphorus, 0.10; and no Chlorine. These elements are all common to meteorites of this type, and so it appears that there has been nothing new or startling revealed to science in Iowa's latest contribution to this particular field of knowledge.

Dr. Nichols, however, did state to the writer, that it was one of the toughest "irons" that the museum technicians had ever attempted to saw, and that the working blade would on occasion apparently make little or no progress for hours at a time. This he said might possibly be due to inclusions of microscopic diamonds (crystallized carbon), of which there was a sufficient quantity shown in the chemical analysis to account for the phenomena, but that no test had yet been made to prove their presence.

The Mapleton meteorite is now displayed in the cabinets of "Meteorite Hall," of the Chicago Natural History Museum, where it has been assigned the catalog number Me2286. Its weight is stated as 108 pounds, and in addition one fragment of 34 grams, presumably the sample originally sent in by Mr. Meevers. It was sawed into a number of

sections which consist of two "end pieces," of 35.5 and 47 pounds each, and three "slabs" weighing 10 pounds, 7 pounds, and 4290 grams, respectively, all of which have been retained by the museum, with the exception of 20 grams which have been exchanged with H. H. Nininger, of the Nininger Meteorite Laboratory, of Denver, Colorado.

Fortunately, there are many men scattered over the country, like Harvey Meevers, possessing a wholesome bump of curiosity in their make-up, who are continually seeking new facts and uncovering new objects for the benefit of science. Were it not for such individuals the progress of civilization would have been immeasurably retarded. Doubtless many other such "finds" may be lying around over the hills and prairies of the central west, only to await discovery by such men under similar circumstances. We surmise that they may be much more common than we think, but of course that is a question which only time may answer.

JOLIET ASTRONOMICAL SOCIETY, JOLIET, ILLINOIS.

Greenwich Sets the World's Time

By SIR HAROLD SPENCER JONES*

The Royal Observatory, Greenwich, the oldest scientific institution in Britain, was founded in 1675 for the practical purpose of assisting navigation. At that time, a ship at sea could easily be hundreds of miles from its estimated position and the need for a reliable method of finding position at sea had become acute.

The real difficulty was to find the ship's longitude. The rotation of the earth about its axis provides fixed datum points, in the north and south celestial poles from which the latitude can be readily determined; but there is no natural datum from which the longitude can be obtained.

The most practical method that had been proposed for finding the longitude at sea depended upon the measurement of the distances from the moon to nearby bright stars. But the method could not be used because the positions of the stars were not known with sufficient accuracy, and the position of the moon in the sky, as calculated from the best available tables, was liable to large errors.

King Charles II of England, who was interested in all matters that affected the Navy, decided that an observatory should be built in order that the required observations should be obtained. For this purpose he gave a site in the royal park at Greenwich, then a fashionable village in the country, about six miles from London. Sir Christopher Wren, the most famous architect of the day, was entrusted with the design. His building erected in 1675 still stands, though somewhat scarred by

*Astronomer Royal of Great Britain.

German bombs. In the course of years many other buildings have grown up around it.

John Flamsteed, an astronomer of repute, was appointed to make the observations and was given the title of Astronomer Royal. The Royal Warrant for his appointment directing him "forthwith to apply himself with the most exact care and diligence to rectifying the tables of the motions of the heavens, and the places of the fixed stars, so as to find out the so-much desired longitude of places for perfecting the art of navigation."

Flamsteed was given the modest salary of £100 a year, out of which he had to provide his own telescopes and pay for such assistance as he needed. He labored almost single handed for 44 years, with unflagging zeal. His observations were collected and published in three large volumes, under the name "Historia Coelestis Britannica." This was the first great contribution to science given by Greenwich Observatory to the world and it opened a new era in sidereal astronomy.

The purpose for which the Observatory had been established, of observing the positions of the sun, moon, and planets, to enable improved tables of their motions to be constructed and of observing the places of the fixed stars was continued by Flamsteed's successors, Halley, Bradley, Maskelyne, and Pond. These names are all famous in the history of astronomy. Halley's greatest service to human knowledge was the share that he took in bringing Newton's "Principia" before the world; he encouraged and persuaded Newton to write it and defrayed all the costs of its publication. By his investigations on the famous comet that bears his name, he did much to secure the universal acceptance of Newton's theory of gravitation. He predicted that the comet would return about the end of the year 1758. The comet was detected on Christmas Day, 1758, 16 years after Halley's death. Comets had generally been considered sporadic visitors, the harbingers of misfortune. Halley's work proved that they were subject to natural laws and that their movements could be predicted.

Halley was a man of great versatility, interested in all branches of science. He made important contributions to our knowledge of the earth's magnetism and of the tides.

With progressive improvements in instruments and in methods of observation the accuracy of the observations was steadily improved. Bradley raised the work of the Observatory to a very high standard and his observations are the earliest which are of sufficient accuracy to be of use to the astronomer of today. He made two discoveries of the greatest importance; he found that there were small changes during a year in the apparent position of a star, which he correctly explained as the consequence of the finite velocity of light; continuing his observations over many years he showed that there were further small displacements, caused by the wobbling or nutation of the earth's axis.

The problem of determining the longitude at sea was at length solved

in 1763 by the invention of the marine chronometer by James Harrison, the son of a carpenter, who received the prize of £20,000 which had been offered in 1714 by the British Government for a satisfactory method of determining longitude within a specified degree of accuracy. Harrison's chronometer was able to keep accurate time at sea, being unaffected by the rolling or pitching of the ship. This chronometer and the three earlier timepieces made by Harrison are amongst the most treasured possessions of the Royal Observatory.

Nevil Maskelyne, who was Astronomer Royal from 1765 to 1810, introduced in 1767 the *Nautical Almanac,* designed for the use of seamen. This most valuable aid to navigation has been published every year from that date. In 1938 the production of an *Air Almanac* was commenced, adapated to the special requirements of air navigation. The airman does not need to know his position as accurately as the sailor but, because of the high speed of modern aircraft, he requires to deduce his position with minimum of delay after making his observations.

Under George Biddell Airy, Astronomer Royal from 1835 to 1881, Greenwich Observatory entered upon a period of rapid expansion. Since 1675 the Observatory had concerned itself almost exclusively with the purpose for which it had been founded. Some years later, the eminent American astronomer, Simon Newcomb, wrote:

> "The most useful branch of astronomy has hitherto been that which, treating of the positions and motions of the heavenly bodies, is practically applied to the determination of geographical positions on land and at sea. The Greenwich Observatory has been so far the largest contributor in this direction as to give rise to the remark that, if this branch of astronomy were entirely lost, it could be reconstructed from the Greenwich observations alone."

The development of telegraphic communications facilitated the distribution of time. In 1865, hourly time signals were sent over the railway network of the country. Greenwich Mean Time was adopted as the standard time by the railways; for many years it was known as "railway time," for it was not until 1880 that it was adopted as the legal time of Britain. In 1924 a further step in the widespread dissemination of accurate time followed naturally upon the development of broadcasting, Greenwich time signals being broadcast several times daily on all programs of the B.B.C. Special radio time signals for use in navigation are also broadcast twice daily both on long and short waves.

The Talking Clock, installed in 1936 by the Post Office and controlled by time-signals from the Observatory, makes Greenwich time continuously available by telephone; so popular is this service that over 20 millions calls a year are made on the Clock.

In 1840 regular meteorological observations were commenced. In the same year magnetic observations, for the study of the earth's magnetism, were added. These observations were at first made visually

throughout the day and night, but since 1848 continuous photographic registration of the movements of the magnetic needle have been made. These movements were found to depend upon the frequency of spots on the sun; so in 1873 daily solar observations were commenced.

Meanwhile, the need for the general adoption by all countries of the same prime or zero meridian from which longitudes should be measured had become urgent. At a conference called in 1884 by the United States Government, the meridian through the transit instrument of the Greenwich Observatory was adopted as the prime meridian; the Observatory had been so long and closely concerned with the needs of navigation that no alternative was seriously considered.

The application of photography to astronomy and the pioneer work of William Huggins in spectroscopic astronomy caused astronomy to develop in new directions. To meet these needs new and larger telescopes were installed. The determination of star positions by photography; the measurement of the distances of the stars, of their temperatures and of their colors, were among the new types of observations undertaken.

During the long history of the Observatory, London has grown steadily outwards. Greenwich is no longer a village in the country; it is one of London's boroughs. The smoke of a great city and, in peace-time, the brightness of the sky at night caused by artificial lights have made Greenwich an unsuitable place for astronomical observation. Accordingly after the war, the Observatory will be moved into the country, away from the smoke and light of towns. The improved conditions will enable new types of observations to be undertaken, so that the Observatory may continue for further centuries to make important contributions to astronomical and nautical science.

Mars and Saturn at Solar Opposition

By R. B. WEITZEL

When Mars and Saturn are at opposition to the sun within five days of each other there are usually, but not invariably, three geocentric conjunctions of the planets within a period of five months.

If the solar opposition of Mars precedes that of Saturn, then two of the planetary conjunctions in geocentric longitude will be before and one after the oppositions. For example, a solar opposition of Mars occurred on December 8 about four days before that of Saturn on December 12, 177 A.D. There were three geocentric conjunctions of the planets on the following dates, Greenwich civil time, at given longitudes.

177	X 11, 3^h	λ 84°.03
	XI 24, 0	82.02
178	III 2, 16	77.25

If the solar opposition of Mars follows that of Saturn, then one of the planetary conjunctions in geocentric longitude will be before and two after the oppositions. For example, a solar opposition of Mars will occur on January 14, 1946, about two days after that of Saturn on January 12. There will be three geocentric conjunctions of the planets on the following dates, G.C.T., at the given longitudes.

1945	X 27,	0^h	λ 114°.80
1946	I 20,	11	110.77
	III 20,	13	107.95

A list of solar oppositions of Mars and Saturn, limited to cases that yield by computation triple planetary conjunctions in geocentric longitude, is presented. The columns give, in order, year, month, day, hour, Julian day number, longitude of sun, and difference in time between solar oppositions of Mars and Saturn.

	Mars Oppositions					Diff.			Saturn Oppositions					
77	VII	8	7	1749371.29	103°.46	−0	5	77	VII	8	2	1749371.08	103°.17
177	XII	8	2	1786049.08	256.08	+4	13	177	XII	12	15	1786053.63	260.68
180	I	12	3	1786814.12	291.24	−2	15	180	I	9	12	1786811.50	288.58
216	IV	3	11	1800045.46	13.11	+1	9	216	IV	2	2	1800044.08	11.79
380	X	25	17	1860151.71	213.61	+4	11	380	X	30	4	1860156.17	218.13
419	II	21	15	1874149.63	333.85	+2	21	419	II	24	12	1874152.50	336.71
519	VII	15	22	1910818.92	113.72	−1	21	519	VII	14	1	1918817.04	111.92
619	XII	14	21	1947495.88	265.64	+2	8	619	XII	17	5	1947498.21	268.02
622	I	17	13	1948260.54	300.54	−4	7	622	I	13	6	1948256.25	296.06
658	IV	10	11	1961492.46	22.76	−2	11	658	IV	8	0	1961490.00	20.41
756	VII	28	23	1997396.96	128.79	+1	15	756	VII	30	14	1997398.58	130.35
822	XI	1	13	2021598.54	223.23	+0	17	822	XI	2	6	2021599.25	223.95
861	II	27	6	2035596.25	343.19	−0	19	861	II	26	11	2035595.46	342.41
1061	XII	20	4	2108942.17	274.71	+1	1	1061	XII	21	5	2108943.21	275.76
1100	IV	15	21	2122938.88	31.92	−4	16	1100	IV	11	5	2122934.21	27.37
1198	VIII	5	2	2158844.08	138.63	+1	1	1198	VIII	6	3	2158845.13	139.65
1264	XI	7	11	2183045.46	232.97	+1	4	1264	XI	8	15	2183046.63	234.15
1303	III	5	17	2197042.71	352.41	−0	6	1303	III	5	11	2197042.46	352.17
1503	XII	26	15	2270388.63	284.01	+0	9	1503	XII	27	0	2270389.00	284.36
1640	VIII	22	0	2320292.00	149.26	−2	8	1640	VIII	19	16	2320289.67	147.01
1706	XI	25	4	2344492.13	242.53	−2	6	1706	XI	22	22	2344489.92	240.24
1745	III	22	0	2358489.00	1.47	−3	4	1745	III	18	20	2358485.83	358.34
1779	V	12	11	2370958.46	51.48	+2	7	1779	V	14	18	2370960.75	53.68
1946	I	14	1	2431835.04	293.27	−1	20	1946	I	12	5	2431833.21	291.42

Two exceptions to the general rule will be considered. The first relates to an instance when the interval in time between the solar oppositions of Mars and Saturn exceeded five days.

1064	I 23, 3	2109706.96	☉ 309°.57	Mars opposition
	I 18, 3	2109701.13	303.69	Saturn opposition
	$-5^d\ 20^h$	difference		

A conjunction occurred in October, 1063, on direct motion. To determine the likelihood of a triple conjunction, a trial date about four days *before the second stationary point of Mars* was chosen and the result obtained: 1064 III 2, Mars λ 120°.06, Saturn λ 120°.71. The geocentric longitude of Mars is less than that of Saturn; accordingly, one conjunction of the planets occurred before and another after the trial

date March 2, 1604. The dates of the triple conjunction were:

1063	X 25, 11^h	λ 126°.85
1064	II 17, 17	121.38
	III 14, 0	120.33

The second exception relates to a case when the difference in time between the solar opposition of Mars and Saturn fell within the five day limit.

1877	IX 6, 0^h	2406869.00	☉ 163°.46	Mars opposition
	IX 9, 14	2406872.58	166.94	Saturn opposition
	—3^d 14^h	differece		

A conjunction occurred November 4, 1877, at geocentric longitude 343°.75, on redirect motion. To determine the likelihood of a triple conjunction, a trial date about four days *after the first stationary point of Mars* was taken, with the result: August 10, 1877, Mars λ 348°.75, Saturn λ 349°.10. Since the longitude of Mars is less than that of Saturn there was no geocentric conjunction on direct or retrograde motion, the nearest approach thereto is marked by the trial date August 10. However, a triple conjunction of planets occurred in right ascension.

1877	VII 27, 21^h	r.a.	351°.45
	VIII 26, 10		349.85
	XI 4, 4		345.88

An inspection of the table will reveal a recurring interval of 442 years with the characteristics of a cycle as evidenced by the following schema.

Mars synodic revolutions	779.9360 × 207 = 161446.75 days
Saturn synodic revolutions	378.0918 × 427 = 161445.20 days
Julian years	365.2500 × 442 = 161440.50 days
Gregorian years	365.2422 × 442 = 161437.08 days

The cycle may be illustrated by a selection of dates with an extension into the future to round out the series.

	Mars Oppositions		Diff.		Saturn Oppositions	
177	XII 8, 2^h	1786049.08	+4^d 13^h	177	XII 12, 15^h	1786053.63
		161446.80				161444.58
619	XII 14, 21	1947495.88	+2 8	619	XII 17, 5	1947498.21
		161446.29				161445.00
1061	XII 20, 4	2108942.17	+1 1	1061	XII 21, 5	2108943.21
		161446.46				161445.79
1503	XII 26, 15	2270388.63	+0 9	1503	XII 27, 0	2270389.00
		161446.41				161444.21
1946	I 14, 1	2431835.04	—1 20	1946	I 12, 5	2431833.21
		161446.38				161446.08
2388	I 23, 10	2593281.42	—2 3	2388	I 21, 7	2593279.29
		161446.33				161443.59
2830	I 31, 18	2754727.75	—4 21	2830	I 26, 21	2754722.88

For the last entry, the dates of the triple conjunction of Mars and Saturn in geocentric longitude have been computed.

2829	XI 6, 0^h	λ 130°.00
2830	II 19, 17	124.93
	III 24, 3	123.50

In December, 1503, occurred the noteworthy phenomena of three

planets, Jupiter, Mars, and Saturn, successively at opposition to the sun within the space of four and a half days. The data of solar oppositions and planetary conjunctions are grouped.

1503	XII 22, 14^h	☉ 279°.87	Jupiter solar opposition
	XII 26, 15	283.99	Mars solar opposition
	XII 27, 0	284.36	Saturn solar opposition
1503	X 5, 20	☊ 104.40	Mars and Jupiter conjunction
	X 14, 21	107.74	Mars and Saturn conjunction
	XII 25, 0	104.45	Mars and Saturn conjunction
1504	I 17, 19	96.67	Mars and Jupiter conjunction
	II 9, 5	95.03	Mars and Jupiter conjunction
	III 7, 21	100.70	Mars and Saturn conjunction
	V 24, 6	106.42	Jupiter and Saturn conjunction

It is rare for a triple conjunction of Mars and Jupiter to occur in proximity with a triple conjunction of Mars and Saturn.

WASHINGTON, D. C.

The Planets in November, 1944

NOTE: Greenwich Civil Time is used unless otherwise stated. To obtain Eastern War Time, subtract 4 hours; Central War Time, 5 hours, etc. The information is taken from the *American Ephemeris and Nautical Almanac*.

Sun. The sun will continue to move southeastward during this month. Its position will change in right ascension from 14^h 26^m to 16^h 23^m, and in declination from —14° 19′ to —21° 36′. Its course will be through Libra, and at the end the sun will be a short distance north of Antares, thus, naturally, rendering that bright star invisible.

Moon. The phases of the moon will occur as follows:

	d	h
Last Quarter	Nov. 7	18
New Moon	15	22
First Quarter	23	8
Full Moon	30	1

It will be farthest from the earth for the month on November 11 and nearest the earth on November 27.

Mercury. Mercury will be a short distance southeast of the sun at the beginning and will move eastward and southward more rapidly than the sun throughout the month. At the end it will be approaching a position of greatest elongation east of the sun, and may possibly be detected near the western horizon at sunset. Its large southern declination will make this less likely for northern observers.

Venus. Venus, like Mercury, will precede the sun in their eastward motion during the month. It, however, will be far enough east of the sun to be easily visible from the beginning. In fact it will be a brilliant evening star throughout the month. It, too, will be several degrees south of the sun.

Mars. Mars will be in conjunction with the sun on November 14, and hence will be invisible during this period.

Jupiter. Jupiter will be following the sun eastward very slowly. It will move only 16 minutes eastward while the sun moves more than two hours. At the end of the month it will be approaching a position of western quadrature. These circumstances will cause Jupiter to be a bright morning star during November. It will be a short distance east and south of Regulus, and will greatly exceed Regulus in brightness.

Saturn. Saturn, like Jupiter, will be visible in the morning hours. It will rise shortly before midnight and will be west of the meridian at sunrise. It will be near maximum declination north. It will be nearly on the hour circle through Sirius, and nearer Sirius than the pole.

Uranus. Uranus and Saturn, being in the neighborhood of opposition with the sun, will both have slight retrograde motion during November. Uranus will be almost exactly two hours west of the sun and in nearly the same declination. It will be in Taurus and a few degrees northeast of Aldebaran, which may be of assistance in identifying this faint planet.

Neptune. Neptune will hardly be visible this month. At the close it will be four hours west of the sun and therefore will rise before the sun and may be observed just before sunrise. The fact that it will be 18 degrees, on the average, north of the sun will make conditions more favorable for observing it. It will be in Virgo, northwest of Spica.

Occultation Predictions for November, 1944

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1944	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
Nov. 2	193 B.Taur	6.3	8 3.7	..	..	4	8 28.6	..	..	324
3	351 B.Taur	6.2	11 37.1	—0.8	—0.6	68	12 35.4	—0.1	—1.8	287
7	139 B.Canc	6.1	4 25.4	—0.1	+0.9	107	5 25.7	—0.3	+1.5	262
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Nov. 2	193 B.Taur	6.3	7 38.5	..	..	351	7 54.3	..	..	327
2	δ Taur	3.9	12 35.5	—0.4	—1.1	88	13 33.4	—0.1	—0.8	256
2	64 Taur	4.8	13 9.6	+0.1	—2.0	119	13 54.8	—0.3	+0.1	226
3	351 B.Taur	6.2	11 19.0	—1.3	—0.9	88	12 30.0	—0.9	—1.0	263
21	η Capr	4.9	23 8.8	—2.9	—1.5	127	23 54.0	—0.6	+2.1	194

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′

Nov. 2	δ Taur	3.9	12	16.8	—1.4	—2.2	117	13	14.2	—1.3	+1.0	221
2	68 Taur	4.2	13	39.6	—1.0	+0.1	57	14	37.6	—0.3	—1.7	286
3	351 B.Taur	6.2	10	26.4	—2.4	—0.5	101	11	46.2	—2.0	+1.0	237
13	566 B.Virg	6.5	13	22.7	—0.7	+1.7	84	14	18.7	—0.4	—1.2	332
28	μ Ceti	4.4	3	55.6	..	..	122	4	30.3	..	..	178

OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′*

Nov. 2	193 B.Taur	6.3	6	50.5	—1.2	+2.8	32	7	59.4	—2.8	—0.6	281
2	δ Taur	3.9	12	51.5	+0.1	+2.9	132	13	30.7	—0.8	+1.2	214
2	68 Taur	4.2	13	54.8	—0.3	0.0	60	..	..	..	..	..
3	351 B.Taur	6.2	11	26.1	—1.5	—3.1	130	12	21.2	—1.8	+1.5	221
22	BD—19°6024	6.8	1	11.8	—0.9	+1.6	29	..	..	..	..	..
23	BD—12°6374	7.2	21	4.7	—0.9	+1.1	86	..	..	..	..	..
24	BD—11°5997	7.1	5	5.0	—0.5	+0.6	40	..	..	..	..	..
25	BD— 6°6335	6.8	4	39.4	—5.4	—7.8	134	..	..	..	..	..

*Computation by Tecla Combariati and J. Lynn Smith, communicated by Captain J. F. Hellweg, Superintendent U.S. Naval Observatory.

METEORS AND METEORITES

Contributions of the Society for Research on Meteorites

Edited by **FREDERICK C. LEONARD**
Department of Astronomy, University of California, Los Angeles 24

The Puente-Ladron, Socorro County, New Mexico, Aerolite

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ABSTRACT

This paper contains an account of a recently discovered 7.7-gram aerolite (a chondrite) (Puente-Ladron, Socorro County, New Mexico; coördinate number = 1068,344), together with an invitation on the part of the finder to all members of the S. R. M. to participate in a search for additional fragments of the fall.

On May 17, 1944, at about 7:00 P.M., the writer stopped beside the pavement on U.S. Highway No. 85 at a point about 49 miles south of Albuquerque, New Mexico, to eat a lunch. The terrane on both sides of the highway there is almost bare of vegetation, the place being a wind-swept, sandy-clay flat. As is my custom on such occasions, I strolled slowly about, food in hand, and scanned the ground for meteorites, which, after thus indulging my fancy at frequent intervals thruout the past 20 years, I had little hope of finding. I could, however, always justify my efforts by reminding myself that each hour thus spent inevitably brought me one trial nearer to the success that I had always confidently counted upon. My lunch finished, I was returning from the nearby Rio Puerco, where I had gone to wash, when my eye was attracted to the protruding end of a small, dark pebble, which seemed perhaps to justify closer inspection. However, the region was dotted with a considerable sprinkling of dark pebbles, many

of which I had stooped to examine in the course of the past 60 minutes, and my tired back protested! I started on, but turned again. The exposed area of the stone was no larger than a thumbnail and appeared so much like malapi that my interest waned. I took another step toward the car, then, chiding my flagging spirit, I stepped back and stooped over to pick up the little pebble. When I pried it loose from the soil and had a closer view, I knew that it was no mere pebble but a genuine stony meteorite! Twenty years are not too long to wait for the thrill that it gave me to realize that here at last I had made a brand-new meteorite discovery alone and unaided in a region far removed from that of any known fall. A quick mental check of the New Mexico finds assured me that no stony meteorite had been recorded from any point nearer than a hundred miles.

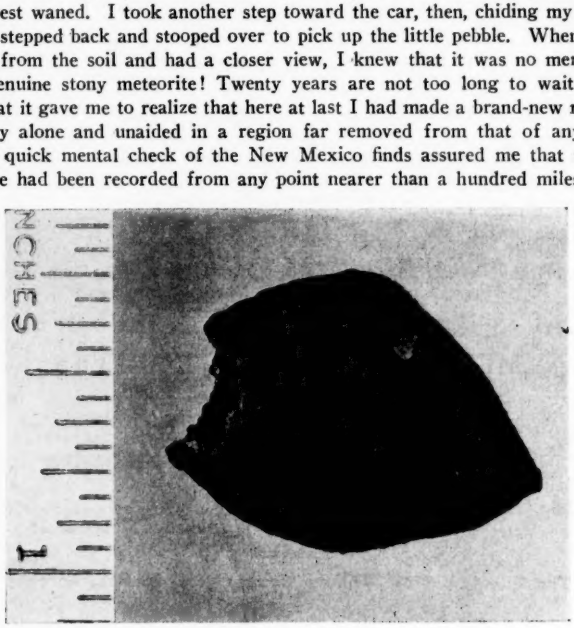

FIG. 1
THE PUENTE-LADRON AEROLITE (ENLARGED)
(Weight = 7.7 grams)

The small size of this specimen (see Fig. 1) makes it seem unwise to attempt any description further than that which can be arrived at by examining the stone intact. By reason of a small break in the fusion crust, the interior of the aerolite is exposed, and this reveals a chondritic structure with some grains of metal and of sulfide. These seem to be embedded in a tuffaceous matrix, as is the case with so many chondrites. The stone appears to have lain in the soil for a considerable time, altho it still retains a reasonably fresh appearance, giving about the same impression of age as did the stones from the Holbrook, Arizona, fall which I gathered in 1931, 19 years after their arrival on the soil. The climate of the two localities is about the same as regards moisture. The crust of the Puente-Ladron stone bears some rust spots, and the stain from the buff-colored soil gives it a generally dark-brown, rather than a black, appearance. No attempt has been made to ascertain the time of fall.

The purpose of this brief account is, first, to place the find on record and, second, to furnish to collectors directions for reaching the locality, which is unusually well suited for a search for meteorites. As I have indicated in previous writings, I believe that no stony meteorite ever penetrates our atmospheric

blanket to reach the soil unbroken—that every fall of stony meteorite is more or less of a shower. There should be a number of stones lying within an area of several square miles adjacent to this find. A complete search may prove that this stone is at an edge of the area or that it is near the middle. Its small size suggests that the former is the case. If this conclusion is correct, then the area in which additional finds may be made may lie in any direction from the point where this specimen was found. Almost certainly, future finds will average larger in size, and stones of any weight up to several pounds are likely to lie on top of the ground, so that a search should prove fruitful. The writer expects to make later visits to this locality, but he is well aware that a complete search is a job for many individuals and not for one. A single person can adequately search an area of about 8 acres in one day. This fact means that 80 days would be required for an examination of only one square mile. Showers have been known to encompass from 5 to 100 square miles. This circumstance indicates that several days of actual searching may be required before even a *second* member of this fall is located!

For the sake of completing the record, the writer requests that any stones found in the vicinity of this fall be reported to him and submitted for comparison with the original find. Any such stones submitted will be returned to the senders as soon as the specimens have been carefully checked for identity. The location of any find should be carefully recorded and described in relation to that of the original discovery, which is herewith detailed with considerable accuracy. South of Albuquerque 48 miles, in Socorro County, U.S. Highway No. 85 is joined by U.S. Highway No. 60, coming from the east. One mile south of this junction on U.S. Highway No. 85 is a bridge across the Rio Puerco. The stone herein described was found 175 paces from the north end of the bridge and 96 paces west of the highway, measured at right angles from a point 150 paces north from the end of the bridge. The spot is marked by a small pile of pebbles and cobblestones picked up in the vicinity.

In choosing a name for this meteorite a problem was encountered in the fact that no village of any seeming permanence exists near the location. Bernardo, which is only a mile away, is shown on maps, but has ceased to be a settlement. Abeytas, 3 miles farther north, is scarcely larger. Contreras and La Joya are about the same distance away, but are on the opposite side of the Rio Grande. The most dominating feature of the entire region is Ladron Peak, about 10 miles away. In view of the recently demonstrated nearness of different meteorite falls in various localities, it seems unwise to select a name from a geographical feature as far away as 10 miles. The Rio Puerco Bridge marks the location very definitely, but there are other bridges across the Rio Puerco on U.S. Highway No. 66 and State Highway No. 6. Consequently, it was determined to combine the word *bridge* with the name *Ladron,* and, since the name *Ladron* is Spanish and combines more euphoniously with the Spanish word for bridge *(puente)* than with the English word *bridge,* we have called the fall *Puente-Ladron.* The weight of the specimen is 7.673 grams. The location, in Socorro County, New Mexico, is at long. W. 106° 51′, lat. N. 34° 24′ (according to the U.S. Highway Department, Denver Office); hence, the coördinate number of the fall is 1068,344.

It is hoped that, when conditions are again favorable for highway travel, a number of persons who are interested in the field aspects of meteoritics will take advantage of the opportunity and contribute to the completion of a search for other specimens of the Puente-Ladron fall. For the benefit of those who are

not accustomed to traveling in the desert, we wish to remind them that it is always wise and often essential to have one's own water supply. The Rio Puerco is dry during most of the year, and the nearest settlements where a safe water supply is available are Belen on the north and Socorro on the south, about 17 and 27 miles distant, respectively. For those who like to collect Indian relics, it will be interesting to know that flakes of flint and one complete arrowhead and a broken spear-point were found in the short time (about 2 hours) that I worked in this area.

In closing this preliminary account, I wish to urge again that all persons who may desire to take advantage of the opportunity afforded here and who may be successful in finding any additional specimens, by all means keep complete and accurate notes regarding the locations of their finds and of the areas examined. Such a procedure will enable other investigators, who may from time to time wish to contribute to the search, to know where most advantageously to apply their efforts, and it will also enable us to prepare for final publication as full an account of the fall as possible.

President of the Society: LINCOLN LA PAZ, Department of Mathematics, Ohio State University, Columbus 10

Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, P. O. Box 9866, Los Feliz Station, Los Angeles 27, California

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VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By **LEON CAMPBELL, Recorder**

RY Sagittarii again Faint: Recent reports from the A.A.V.S.O. members indicate that the R Coronae Borealis-type variable, RY Sagittarii, has again faded away to minimum. The decrease in light evidently commenced early in June, and on July 18 the variable had faded to magnitude 12.0, at an approximate rate of four magnitudes in twenty-two days. The variable had barely attained full maximum brightness ere it underwent another diminution in light. The previous decrease in magnitude occurred in August, 1942, when the fading away was moderately slow, and subject to marked irregularities before reaching minimum, which, during that phase, was not recorded at a magnitude fainter than 10.4. (See these notes for October and December, 1942.)

SS Cygni in 1943: The prototype of nova-like, or geyser-like, stars, SS Cygni, passed through five maxima in 1943, as listed in Table I. The average length

TABLE I

OBSERVED MAXIMA, 1943

No. Max.	Type	J.D. 10.0 I	Diff.	J.D. Max.	Diff.	J.D. 10.0 D	Diff.
330	A2	2430728	97	2430731	94	2430736	89
331	C4	0778	50	0784	53	0792	56
332	A4	0849	71	0853	69	0857	65
333	A9	0951	102	0956	103	0966	109
334	A4	1029	78	1031	75	1036	70

of the cycles for this particular year, as indicated by these maxima, is 78.7 days, a value appreciably larger than that noted in recent years, or than the average value of 51.7 days over the nearly fifty-year interval elapsed since the discovery of the star in 1896. In fact, the average cycle for the last nine maxima observed to date (July 25) is a full eighty days, tending to confirm the impression gained in 1934 from a lengthy discussion of the light curve, that long cycles occur at intervals of approximately 3000 days or 60 cycles.

The observations, 730 in number, are listed in Table II under single day means, and the light curve is shown in the figure.

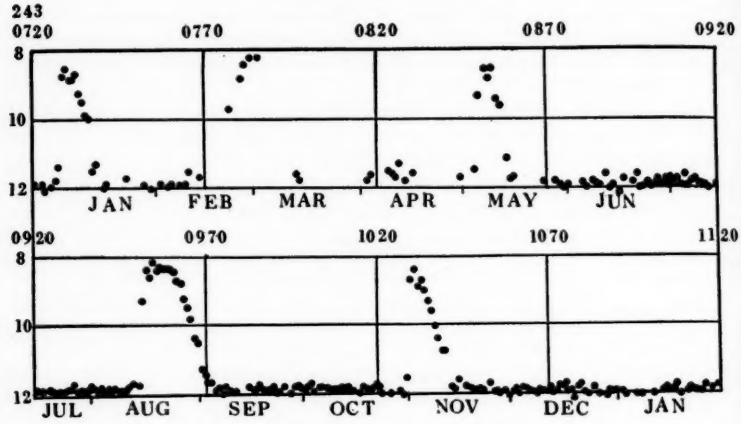
TABLE II

DAILY MEANS OF SS CYGNI, 1943

243	—0—	—1—	—2—	—3—	—4—	—5—	—6—	—7—	—8—	—9—
0720	3 11.87	.....	1 11.9	1 12.1	.....	1 12.0	3 11.80	2 11.40	4 8.75	2 8.55
0730	3 8.83	6 8.82	3 8.63	5 9.26	4 9.50	5 9.92	1 10.0	1 11.5	1 11.3	.....
0740	1 12.0	1 11.9	.....	.....	.....	.....	.....	3 11.73	.....	.....
0750	.....	.....	1 11.9	.....	1 12.0	.....	.....	2 11.85	.....	1 12.0
0760	1 11.9	.....	1 11.9	.....	2 11.90	1 11.5	.....	.....	1 11.7	.....
0770	.....	.....	.....	.....	.....	.....	.....	1 9.7	.....	.....
0780	1 8.8	1 8.4	.....	1 8.2	.....	1 8.2	.....	.....	.....	.....
0790	.....	.....	.....	.....	.....	.....	1 11.6	1 11.8	.....	.....
0800	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0810	.....	.....	.....	.....	.....	.....	.....	1 11.8	1 11.6	.....
0820	.....	.....	.....	1 11.5	1 11.6	1 11.7	1 11.3	.....	1 11.8	.....
0830	1 11.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
0840	.....	.....	.....	.....	3 11.70	.....	.....	.....	1 11.5	1 9.3
0850	.....	1 8.5	1 8.8	1 8.5	.....	2 9.40	1 9.6	.....	1 11.1	1 11.8
0860	1 11.7	.....	.....	.....	.....	.....	.....	.....	.....	1 11.8
0870	.....	.....	1 11.8	.....	1 11.9	1 12.0	2 11.90	.....	.....	.....
0880	2 11.80	3 11.97	.....	2 11.80	3 11.83	1 11.9	.....	2 11.55	1 12.0	2 11.90
0890	.....	2 12.10	1 11.7	.....	.....	1 11.8	1 11.6	2 12.00	6 11.97	9 11.79
0900	6 11.95	2 11.90	1 11.7	1 11.9	3 11.87	3 11.93	6 11.70	3 11.90	3 11.73	3 11.90
0910	1 11.6	2 11.90	4 11.78	3 11.73	7 11.83	4 11.88	4 11.92	1 12.0	1 12.0	1 11.9
0920	3 11.90	.....	1 11.9	1 12.0	4 11.88	3 11.90	3 11.90	3 11.93	4 11.92	5 11.88
0930	2 11.90	3 11.77	7 11.91	5 11.90	3 11.93	2 11.85	11 11.78	5 11.84	6 11.89	2 11.80
0940	4 11.95	4 11.82	8 11.94	9 11.81	7 11.89	4 11.90	5 11.92	1 11.8	1 11.7	.....
0950	4 11.78	3 9.30	4 8.38	2 8.60	7 8.16	6 8.40	9 8.31	7 8.36	7 8.36	8 8.40
0960	8 8.46	6 8.69	8 8.78	9 9.24	4 9.52	8 9.81	3 10.40	7 10.56	9 11.32	5 11.46
0970	3 11.63	2 11.65	2 11.90	3 11.80	1 12.0	1 11.80	3 11.90	.....	2 11.90	.....
0980	.....	.....	1 11.8	1 11.9	2 11.85	5 11.74	5 11.90	8 11.91	4 11.92	2 11.80
0990	5 11.98	4 11.95	4 11.80	.....	3 12.00	7 11.81	6 11.78	6 11.85	1 11.9	1 11.8
1000	3 11.70	2 11.95	4 11.82	2 11.80	3 11.83	2 11.85	2 11.90	1 11.9	3 11.90	1 11.8
1010	2 11.95	1 11.8	1 11.9	.....	1 12.0	1 11.8	2 11.85	2 11.90	4 11.82	1 11.7
1020	1 11.8	1 12.0	3 12.00	3 12.0	.....	.....	2 11.90	8 12.02	4 11.50	11 8.69
1030	7 8.39	1 8.9	3 8.73	3 9.00	2 9.30	3 9.60	5 10.06	1 10.4	2 10.75	2 10.75
1040	.....	1 11.8	2 11.85	3 11.60	.....	1 11.8	3 11.83	4 11.92	5 11.90	2 11.85
1050	1 11.9	.....	2 11.70	5 11.98	7 11.96	2 12.00	.....	1 11.9	3 12.07	3 11.93
1060	3 11.83	1 12.0	1 11.8	3 11.83	4 11.92	2 11.95	2 12.00	1 11.9	1 11.9	.....
1070	1 11.8	1 12.0	3 11.90	2 11.75	3 11.77	4 11.92	3 11.89	1 12.1	2 11.80	2 11.70
1080	2 11.95	4 12.00	4 11.88	3 11.80	1 12.0	.....	2 12.00	3 11.90	5 11.90	3 11.90

The Long-Period Variable RT Cygni: Miss Marjorie Pettit has recently studied in detail the long-period variable RT Cygni, first, to determine whether or not an accurately observed light curve would reveal with certainty the existence of small fluctuations, secondly, to obtain the mean light curve over the past 43 cycles in order to note any possible recurrent irregularities, and thirdly, to determine as many physical properties of the star as possible.

A six-inch refracting telescope with a visual wedge photometer was em-



LIGHT CURVE OF SS CYGNI IN 1943

ployed in securing as frequent observations as possible, the probable error near maximum being of the order of ±0.06 mag., and near minimum ±0.07.

Miss Pettit's curve of a single cycle, covering the time from June 21, 1943, to April 29, 1944, shows four well-defined humps, although not of large extent. The curve is slightly less smooth than that covering the same interval of time derived from the ten-day means of the A.A.V.S.O. observations. This is to be expected, since mean curves tend to smooth out irregularities, especially when the observations are made by different persons.

Miss Pettit also illustrates a composite curve of the ten-day means of all the A.A.V.S.O. observations covering 42 cycles, which well show the general characteristics of the light curve. It is recognized that there are differences in the form of most long-period variables from cycle to cycle, more marked in some stars than in others.

The average period of RT Cygni derived by Miss Pettit is the same as that obtained at Harvard, namely 190.4 days, but she states that the most probable value is 182.5 days, ranging from 161 to 219. The star varies in light from an average magnitude at maximum of 7.39, to 11.94 at minimum, an average range of 4.55 magnitudes. These values are in close agreement with those derived at Harvard.

Probably the most interesting feature of Miss Pettit's discussion of RT Cygni, is the result obtained from a study of the spectrum of this star. The spectrum near Maximum light is M2e, not unlike that of α Orionis, and near minimum it is M6e, a type somewhat later than α Herculis.

She deduces an absolute magnitude for the star of —4.6 at average maximum, a parallax of 0".00040, a distance of 8100 light years, a diameter of 610 to 1400 times that of the sun, and a temperature of 2010° to 3000° K, dependent on brightness. The mass is estimated as 16.2 times the sun, and the mean density, 7×10^{-8} to 6×10^{-9} ⊙. The space velocity is 220 km/sec.

Miss Pettit's study of this star reveals some interesting facts, and similar studies of other long-period variables would be of great value.

Observations: Summary of observations, as contributed during the months of May and June, 1944, by 41 observers, is given below.

Observer	May—1944—June Var.	Ests.	Var.	Ests.	Observer	May—1944—June Var.	Ests.	Var.	Ests.
Blunck	11	11	14	17	Lovinus	6	6	...	...
Boone	13	13	...	...	Luft	7	36	8	47
Bouton	35	43	23	34	Manlin	...	...	23	32
Buckstaff	8	12	12	32	Mary	10	10	23	23
Buechner	14	14	28	30	Meek	31	101	...	...
Chrisman	...	...	5	7	Nadeau	108	116	106	148
Copes	3	3	...	...	Oheim	20	61	23	55
Cousins	...	...	25	48	Parker	23	23	39	39
Dafter	...	...	9	50	Parks	23	92	17	30
Fernald	264	484	254	589	Peltier	155	207	131	155
Ford	21	23	33	38	Peters	6	6	14	14
Garneau	25	25	44	44	Robinson	27	30	...	...
Harris	31	31	14	14	Rosebrugh	24	126	13	84
Hartmann	101	105	103	104	Schoenke	7	7	25	31
Holmes	8	8	...	...	Sill	94	94	105	106
Holt	71	105	75	91	Topham	8	8	...	...
Howarth	15	15	17	17	Vohman	32	40	15	19
Huffer	7	7	...	...	Webb	9	10	15	24
Kearons	39	52	26	43	Weber	96	96	77	77
Kelly	11	15	11	15					
de Koch	...	...	67	272	Totals		2069		2355
Koons	34	34	26	26					

July 25, 1944.

Additional Note on RY Sagittarii: It appears that RY Sagittarii reached a minimum magnitude of 12.5 on July 25, and almost immediately began to increase in light, and on August 27 it had attained magnitude 8.7, when it apparently began another descent toward minimum. The star should be carefully observed so as to note its activities before it reaches full maximum brightness.

Observations for July and August: A total of 5,867 observations were contributed by 43 observers during July and August, as listed herewith:

Observer	July—1944—August No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	July—1944—August No. Var.	No. Ests.	No. Var.	No. Ests.
Ball	..	..	10	10	Kearons	41	43	70	130
Bappu	25	123	..	..	Kelly	9	14	12	19
Blunck	19	23	29	33	Kennedy	2	2	..	..
Boone	24	24	23	23	de Kock	70	358	72	294
Bouton	25	26	23	31	Koons	44	51	51	64
Buckstaff	22	57	25	94	Luft	9	136	12	154
Buechner	..	..	16	19	Manlin	23	23	..	..
Chrisman	..	..	7	7	Mary	22	24	34	34
Cousins	50	205	46	144	Meek	31	130	31	180
Duffie	25	36	14	23	Nadeau	21	21	99	113
Fernald	238	545	247	470	Oheim	51	112	61	149
Ford	10	10	30	32	Oravec	4	4	4	6
Garneau	45	51	34	36	Parks	28	48	26	48
Halback	31	31	23	23	Peltier	77	117	121	173
Harris	23	23	28	28	Peters	..	..	12	15
Hartmann	120	140	128	137	Rosebrugh	9	55	8	88
Holmes	11	11	11	11	Schoenke	23	37	33	49
Holt	50	81	77	158	Segers	..	..	26	113
Howarth	16	17	14	14	Sill	62	62	79	79
Huffer	12	12	..	..	Vohman	16	19	18	19

Observer	July—1944—August No. Var.	No. Ests.	No. Var.	No. Ests.
Webb	16	16	25	30
Weber	62	62	79	79

Observer	July—1944—August No. Var.	No. Ests.	No. Var.	No. Ests.
Weitzenhoffer	..	..	2	7
	43	(Totals)	2741	3126

September 15, 1944.

Comet Notes

By G. VAN BIESBROECK

No new comets have been announced since the last report and there are none in reach of ordinary telescopes for northern observers.

In the June issue (p. 311) mention was made of the scanty information known at that time concerning COMET VÄISÄLÄ. With a delay of several months an orbit was received here early in August; it was computed by Miss Oterma from observations 1944 April 18 and 26 (Turku) and May 27 (Sonneberg) with the result:

$$\begin{aligned} T &= 1945 \text{ January } 2.514 \text{ U.T.} \\ \omega &= 238^\circ.860 \\ \Omega &= 28.470 \quad (1950.0) \\ i &= 17.183 \\ q &= 2.4021 \end{aligned}$$

On computing an ephemeris from these elements I found that there was still a slight chance of catching the comet before it went too far south. It was recorded at very low altitude, shortly after sunset, on August 7 at which time the ephemeris required a correction of -1^m5 and $+11'$. The comet appeared as a small round nebulosity of magnitude 13.5, a figure which is uncertain in view of the circumstances of observation. Another observation was secured at the Lick Observatory by G. Herbig on August 12 but this will presumably remain the last one before the comet goes into hiding behind the sun for several months. The orbit indicates, however, that further observations are to be expected next spring.

PERIODIC COMET SCHWASSMANN-WACHMANN 1925 II becomes visible again in the second half of the night. It was recorded here August 18 and 19 as a small nebulosity of magnitude 15 close to the position predicted by Dr. P. Herget in his ephemeris given on p. 312 of the June issue. It is continued here:

	h	m	°	′
1944 Sept. 27	3	31.0	+29	58
Oct. 13		26.6	30	4
29		19.9	29	56
Nov. 14		12.0	29	34
30	3	4.3	28	59
1944 Dec. 16	2	58.1	28	20
1945 Jan. 1	2	54.3	+27	43

The location northwest of the Pleiades is most favorable this season so there will be a good opportunity to follow the expected rapid changes in brightness, which have characterized this unique object.

COMET DU TOIT, which has been followed in the southern hemisphere since its discovery last May, now comes gradually in reach of northern observers. From three of his observations May 29, June 28, and July 28, F. J. Bobone has deduced

a further improvement of the orbit leading to the following elliptic elements and ephemeris (*Harv. Ann. Card* 692):

Time of perihelion	1944 June 17.49027 U.T.	
Longitude of node	22° 22′ 55.″0	1944.0
Node to perihelion	257 0 39.6	
Inclination	18 45 8.4	
Eccentricity	0.7887823	
Perihelion distance	1.2771421 A.U.	

EPHEMERIS

	h m	° ′
1944 Oct. 1	23 11.4	−25 7
9	7.6	22 9
17	6.2	19 25
25	6.9	16 53
Nov. 2	9.3	14 33
10	23 13.1	−12 24

It is seen that the comet moves northward through Aquarius. No recent data on brightness are available yet but the object is losing in light as it recedes both from the sun and the earth. The elements correspond to a period of 14.868 years and the eccentricity is such that the orbit extends beyond the planet Saturn at aphelion.

The same computer Bobone has improved the orbit of COMET VAN GENT from a longer arc of observations. The change is slight from the parabolic elements given on p. 354 of the August issue and not until the end of this year will the comet have emerged sufficiently from the vicinity of the sun to allow further observations in the morning sky.

Williams Bay, Wisconsin, September 12, 1944.

General Notes

Professor S. A. Mitchell, who is retiring after serving for thirty years as director of the McCormick Observatory of the University of Virginia, has been presented by colleagues, former students and friends with an album containing a hundred and twenty-six letters of appreciation.

(*Science*, September 8, 1944)

Dr. Harlow Shapley, director of the Harvard Observatory, was presented by the Mexican Government with the Order of the Aztec Eagle, third class, at a reception given on July 22 by the Mexican ambassador and Senora de Castillo Nagera, in recognition of his cooperation in arranging for the installation of the telescope of the National Astrophysical Observatory at Tonanzintla

(*Science*, July 28, 1944)

Astronomical Lectures

An unusual opportunity is afforded those persons who live in or near New York City, who are interested in a course in astronomy. Such a course is scheduled to be given at the School of Philosophy and Liberal Arts, 66 West Twelfth street, New York City, beginning on Monday, October 2. Fourteen other lectures will follow on succeeding Mondays, beginning at 8:20 P.M. The lectures are to be given by Dr. Peter van de Kamp, director of the Sproul Observatory, Swarth-

more College, a recognized authority in his field.

Dr. van de Kamp will discuss the following topics in order: 1. Observing the Stars; 2. Distances and Motions; 3. Double and Multiple Stars; 4. Solar System; 5. Law of Gravitation; 6. Spectral Analysis; 7. The Nearer Stars; 8. Terrestrial Physics and Chemistry; 9. Stellar Atmospheres and Interiors; 10. Source of Stellar Energy; 11. Location by Geometric and Photometric Methods; 12. Systematic Motions; 13. The Arrangement of Stars and of Globular Clusters; 14. The Rotating Milky Way System; 15. Status of Sun among Stars.

Further information concerning this series of lectures may be secured by writing to Miss Clara W. Mayer, Dean, at the address given above.

The Warner and Swasey Observatory of the Case School of Applied Science, Cleveland, Ohio, will be open to the Public on the following Thursday and Friday nights during the year: September 28 and 29—"The Moon, Our Nearest Neighbor"; October 26 and 27—"The Solar Family"; November 23 and 24—"Cosmic Dust in Space"; January 25 and 26—"The Sun, Our Nearest Star"; March 22 and 23—"Families of Stars"; April 26 and 27—"Stars that Vary in Brightness"; May 24 and 25—"The Summer Sky"; June 21 and 22—"The Milky Way."

The Observatory will be open at 7:45 P.M. Lecture will be at 8:00 P.M. Observations will be made through the telescope after the lecture when conditions are favorable. Reservations may be made by calling Case School of Applied Science, GArfield 6680. The Observatory is located on Taylor Road two blocks South of Euclid Avenue.

The Royal Astronomical Society has awarded its Gold Medal for 1944 to Dr. Otto Struve, Director of the Yerkes Observatory; it is to be noted that Otto Struve is the fourth Struve to be so honored. Dr. S. Chandrasekhar has been elected a Fellow of the Royal Society of London. Miss Antonia C. Maury has been awarded the Annie Cannon Medal of the American Astronomical Society; the award was made in recognition of her important contributions to the field of spectral classification. (*Monthly Astronomical Newsletter*, July, 1944)

Book Review

Clouds and Weather Phenomena, by C. J. P. Cave. (Cambridge, England, at the University Press; New York, The Macmillan company. $1.75.)

This small volume of 44 pages consists of 22 pages of text and 22 pages of photographs of clouds. This is, indeed, a commendable arrangement in this case, for a picture of a cloud does much toward giving meaning to a description of it. The ability to recognize the various types of clouds and to know what they very likely portend as to approaching weather conditions brings the same satisfaction as does the recognition of the stars and the constellations at night. This volume also furnishes simple introductory statements regarding such atmospheric phenomena as rainbows, mirages, haloes, and even the very modern phenomenon of the condensation trails of high-flying planes. The book should be read and then kept near at hand so that the photographs of the clouds may be available as aids in identifying the clouds in the sky. It contains much interesting information. C.H.G.